The Journal of Parasitology

Volume 30 December, 1944 Number 6

THE TROMBICULID MITES (CHIGGER MITES) AND THEIR RELATION TO DISEASE[1]

H. E. Ewing

Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, United States Department of Agriculture

The subject of this address, "The Trombiculid Mites and Their Relation to Disease," is one in which the speaker has long been interested as an investigator. It is believed to be timely, and can with propriety be regarded as a part of the symposium on "Parasitology in Relation to the War" which is held here this morning.

Under the name of chiggers, or redbugs, the larvae of our common trombiculid mite are doubtless familiar to most of our members who live in the Southern States. Here they long have been known as an annoyance to man because their attacks cause a skin eruption and intense itching; but, if this were the only kind of injury caused we would have no great interest in them as wartime pests. It is now known, however, that in several parts of eastern Asia and the islands of the Pacific other similar species transmit a disease frequently fatal to man.

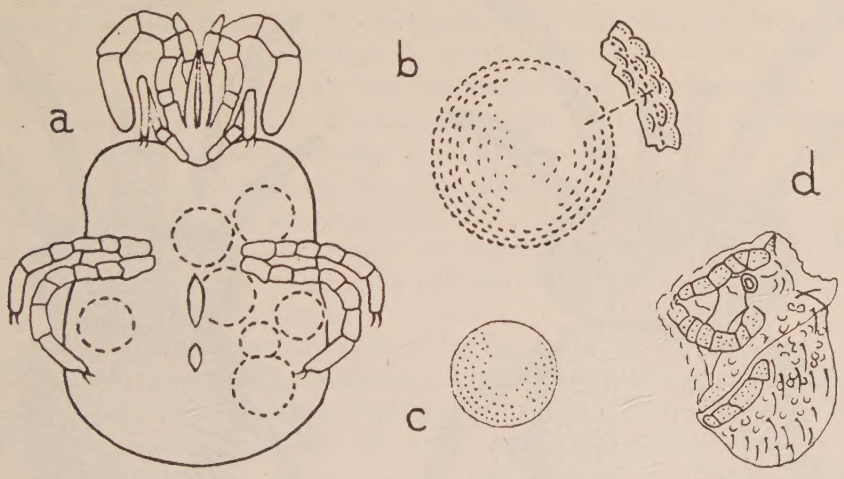


Fig. 1. *a,* female of *Trombicula akamushi,* showing more than one fully formed egg, ×40 (after Kawamura and Ikeda); *b,* egg (with detail of chorion) that was forced through a rupture of abdomen of *Eutrombicula goldii; c,* egg of *E. alfreddugèsi* fully formed in the abdomen of female; *d,* larva of *T. akamushi* yet enclosed in cuticular exuviae of embryo, but after casting its chorion, or eggshell, ×90 (after Miyajima and Okumura). Figures *b* and *c,* ×100. (Original.)

Received for publication, October 26, 1944.

[1] Address of the retiring President, American Society of Parasitologists, September 12, 1944, Cleveland, Ohio, being also a part of the symposium on "Parasitology in Relation to the World War."

LIFE HISTORIES

The chigger, or larval stage of a trombiculid mite, is the only one that is parasitic and is the only one usually detected in nature by the general entomologist or parasitologist. This is because the other stages—the nymph, adult, and egg—are concealed in the soil.

The eggs from which the larvae hatch usually are produced one at a time in the body of the female, but according to Kawamura and Ikeda (1936) in the common

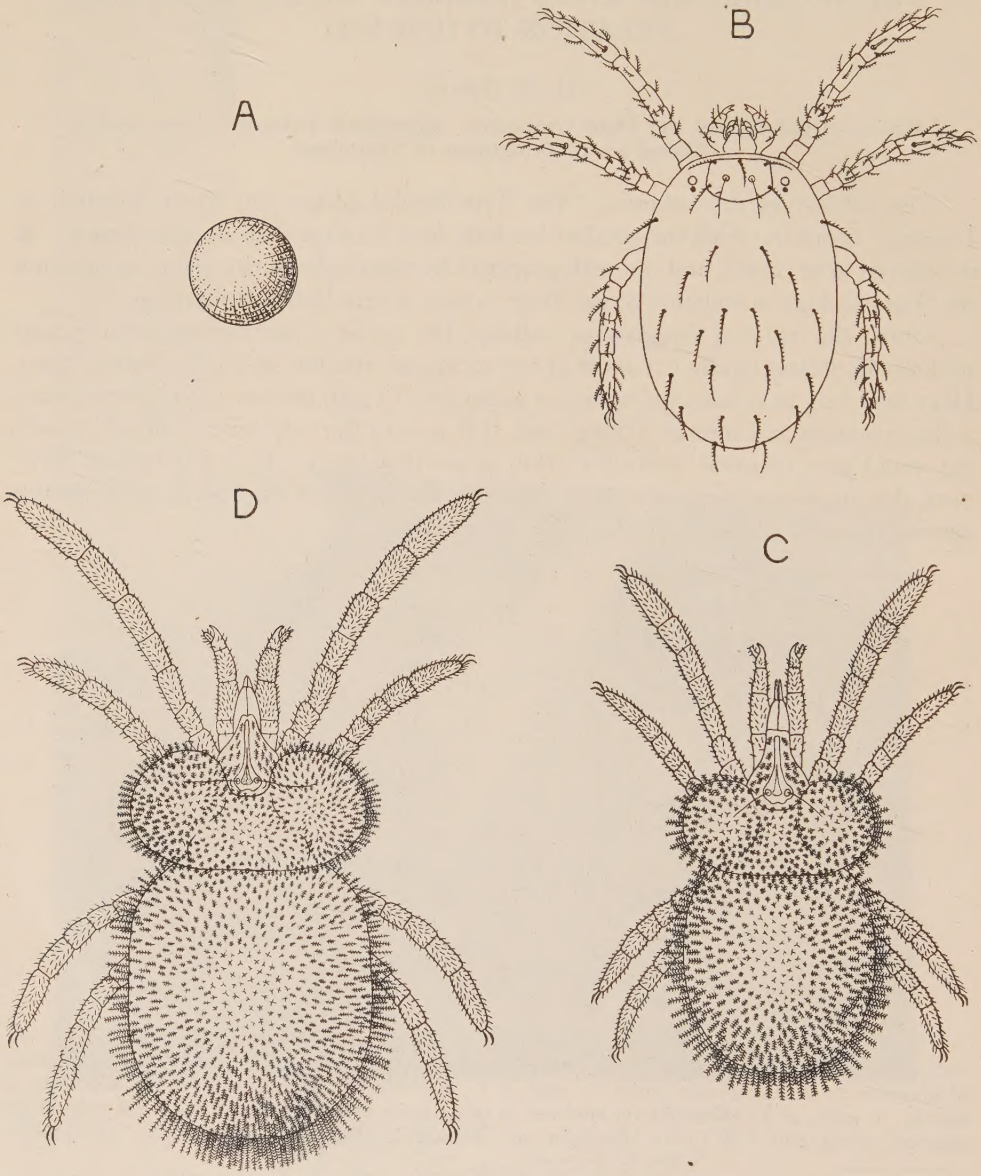


FIG. 2. The different stages in the life cycle of *Eutrombicula alfreddugèsi; A,* fully developed egg as found inside of abdomen of female, ×100; *B,* larva reared from isolated female, ×100; *C,* a nymph reared from a larva on a young toad, *Bufo* species, ×70; *D,* adult reared from a larva on a box turtle, *Terrapene carolina,* ×60. (Original.)

Japanese trombiculid, *Trombicula akamushi* (Brumpt), more than one egg (Fig. 1, *a*) may reach full development at a time. The egg (Fig. 1) of the different species are very minute and spherical but may have a thick chorion.

Miyajima and Okumura (1917) have described a deutoval stage as occurring in the life cycle of *T. akamushi.* However, what they observed (Fig. 1 *d*) is really nothing more than the cast cuticular exuvia of the fully developed embryonic larva. This is observed in many of the more generalized insects and is not a true deutovum, as is found, for example, in the spiders and certain other arthropods.

The trombiculid larva (Fig. 2, *B*) is very different in its structure from the succeeding stages. It is very small, seldom being more than two-fifths of a millimeter in length, has only six legs, and the chelicerae possess recurved, hooklike processes or teeth. The body bears a conspicuous dorsal plate and is sparsely clothed with setae.

In the best studied trombiculid mite, *Trombicula akamushi,* a quiescent stage is known to intervene between the larva and the active nymph. At least Miyajima and Okumura (1917) have figured such a stage which is known as the nymphochrysalis. Apparently this stage is homologous with the protonymph of many other kinds of mites. In the formation of the nymphochrysalis the appendages and some of the inner structures of the body undergo histolysis. These appendages are reformed not inside the appendicular shells of the cast larval skin but instead under the cuticle of the body. Also, the appendages of the nymphochrysalis are not distinctly segmented, and they, as well as the body proper, are devoid of setae. The nymphochrysalis is inactive and always is found inside the old larval skin.

Active nymphs (Fig. 2, *C*) of several species of trombiculids have now been reared both in the New and in the Old World. They differ greatly from the larvae in being much larger, and in having four pairs of legs. In addition the body has numerous setae, and instead of the dorsal plate, a dorsal crista and area sensilligera (Fig. 3) are present. Morphologically nymphs differ from adults in the following three respects: They are smaller; each has but two pairs of genital suckers instead of the three present in the adult; and each palpal tibia has only two subterminal spines (Fig. 3), instead of the three or four found in the adult.

The adults resemble the nymphs very closely not only in structure but also in habits and the two sexes are remarkably alike. In fact, but few investigators have ever mentioned the sexual differences. However, if the genital area of a well-cleared and stained specimen is examined, certain chitinized structures are clearly revealed (Fig. 4) that indicate the sex.

Concerning the numerical ratios of the two sexes but little is known. Among the adults of *Eutrombicula alfreddugèsi* in the United States National Museum collection, which came from various localities in the United States, 25 individuals could be clearly determined as to sex. Of these, 13 are males and 12 females.

OUR PRESENT KNOWLEDGE CONCERNING THE LIFE CYCLE OF *Eutrombicula alfreddugèsi* (OUDEMANS)

This occasion is probably an opportune one for summarizing what is known on the life cycle of our common North American chigger, *Eutrombicula alfreddugèsi* (Oudemans). The first published report on this matter was in Science (**59** (1515): Sup. p. XIV) in 1924 and contained a statement that I had found the adult of our common chigger. This referred to results which were published early the following

year (Ewing, 1925a) and in which the following facts were presented: Adult females, collected from places where there was a known infestation of *E. alfreddugèsi,* were isolated in individual breeding cells and kept alive from several to many days. From two such females several larvae of *E. alfreddugèsi* were obtained.

The nymphs of *E. alfreddugèsi* probably were first reared by Miller (1925a and 1925b). In some very important experiments, in which for the first time snakes

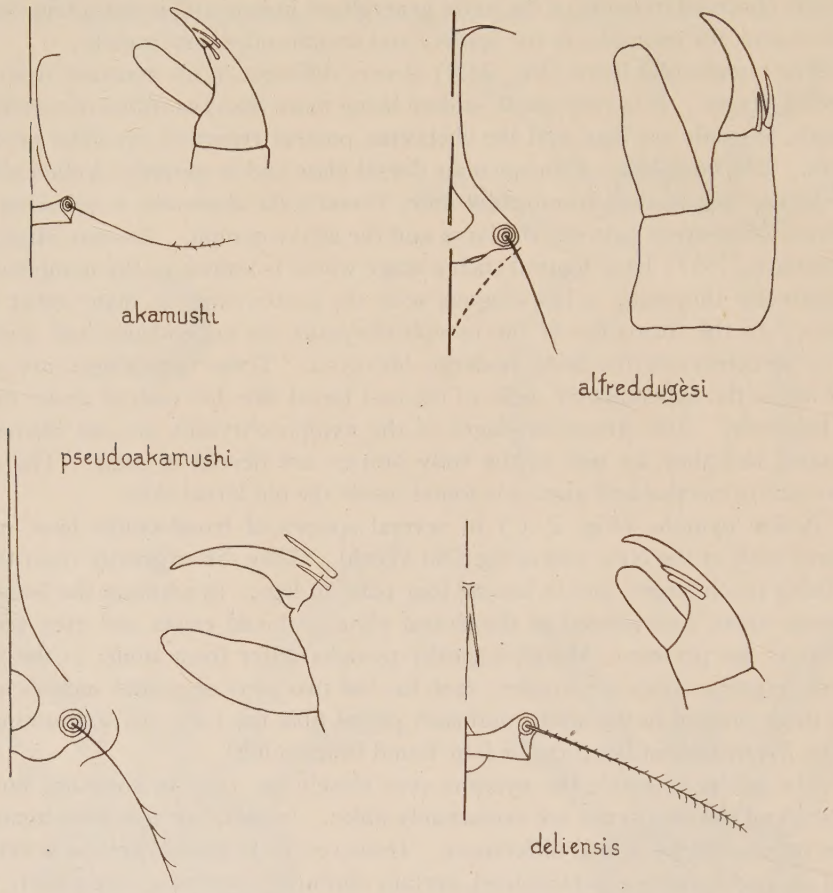


FIG. 3. Drawings (greatly but not equally enlarged) of the crista and area sensilligera (right half of each), and the distal portion of the palpus (dorsomedian views) of nymphs of four species of trombiculids. Those of *Trombicula akamushi* (Brumpt) are after Miyajima and Okumura, 1917; of *T. deliensis* Walch, after Walch, 1924; of *Eutrombicula pseudoakamushi* (Hatori), original from a specimen reared by Walch; of *E. alfreddugèsi* (Oudemans), original from specimens reared by the writer.

were shown to be natural hosts of our common chigger, he reared nonparasitic individuals. These he regarded as adults, claiming that the nymphal stage was absent. While this conclusion was evidently in error, Miller's experiments were of much importance since for the first time a nonparasitic form of an American trombiculid was reared from the parasitic larvae.

The year following, the writer (Ewing, 1926a) reared many nymphs and two adults of *E. alfreddugèsi* from live infested box turtles, *Terrapene carolina* (Linnaeus), taken at North Beach, Md. It was found at that time that "the chiggers

engorge rapidly on the box-turtle and drop off without difficulty." On the other hand, on snake hosts the chiggers had been found to engorge very slowly and to detach themselves with difficulty.

Since rearing the nymphs and adults from our common box turtle, I have reared nymphs alone from young toads, *Bufo* species. These rearings were as follows: On three occasions infested live young toads were collected at Great Falls, Va., during the months of July and August. From a total of 48 young toads thus taken 5 active nymphs were reared.

It will be noted that in these various rearing experiments it was easy to obtain nymphs from engorged larvae which had dropped from the host individuals, but

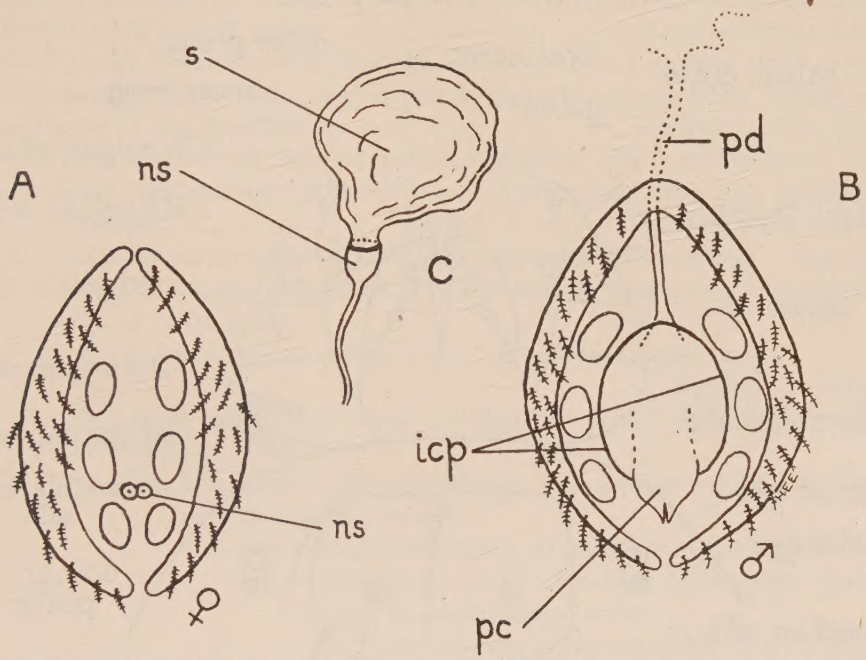


FIG. 4. Structures about the genital openings of adults of *Eutrombicula alfreddugèsi* (Oudemans); *A*, of female (inner genital plates not shown); *B*, of male (inner genital plates not shown); *C*, detail of a (?) sacculus of female. Lettering as follows: *icp*, internal chitinous plates lining genital opening; *ns*, neck of (?) sacculus (in *A*, deeply stained in natural position from below; in *C*, seen in profile); *pc*, penal cone; *pd*, duct of penis; *s*, (?) sacculus. All greatly enlarged. (Original.)

from the large number of larvae obtained by the writer from more than 50 individual hosts (box turtles and young toads combined) only 2 adults were reared. These results are typical of those obtained by other workers; in all cases considerable difficulty was experienced in obtaining adults.

Although particular efforts were made in some of the rearing experiments to induce females of *E. alfreddugèsi* to deposit eggs, none was obtained. In fact, I have never seen the egg of our common chigger mite except in the body of the female.

Now to summarize, the instars involved in the life cycle of our common North American trombiculid as known at present are the undeposited egg, the larva, the active nymph, and the adult. There remains to be found the deposited egg (if eggs are in reality deposited) and the nymphochrysalis (if such a stage really exists).

CLASSIFICATION

The classification of the trombiculid mites can be regarded as beginning with the establishment of the oldest included genus, *Trombicula* Berlese (1905). When Berlese established this genus, and for several years thereafter, it was not known that the adults, upon which it was based, were the parents of chiggers. In his review of the adult forms of the whole family TROMBIDIIDAE, Berlese (1912) divided *Trombicula* into two subgenera, which together included six species. In the same year Oudemans (1912) published his summary of what was known of the larvae of the two families TROMBIDIIDAE and ERYTHRAEIDAE. It is in this comprehensive work

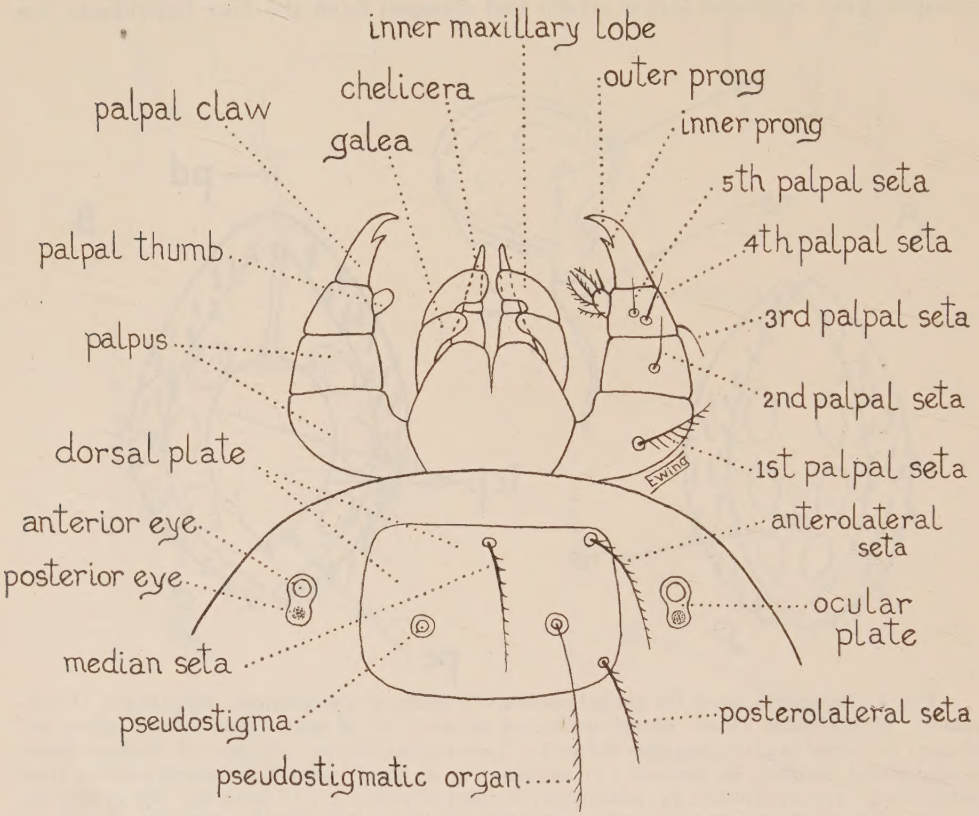


FIG. 5. Drawing of anterior part of larva of *Eutrombicula göldii* (Oudemans), dorsal view, with setae omitted on left side. (Greatly enlarged and with structures labeled.) (Original.)

that the trombiculid larvae receive their first extensive treatment, yet, strange to say, the name TROMBICULA is not mentioned in its pages. The time had not yet arrived for the proper association of the larval forms with the adults.

When the subfamily TROMBICULINAE was established (Ewing, 1929b) and its six genera keyed out, several species had been reared to the nymphal stage and a few to the adult. Later this key was expanded (Ewing, 1938b), in the form of a classification, to include 15 genera.

Womersley and Heaslip (1943) in their extensive paper on the trombiculid mites of the Austro-Malayan and Oriental Regions recognize 19 genera of the TROMBICULINAE, including the genus *Myotrombicula,* which was described as new. This genus was established for a very unusual species in which the chelicerae and palpi are said

to be modified for hair clasping. Although the genus apparently belongs to the TROMBICULIDAE, I have been unable to place it properly in the key to genera here given.

Recently (Ewing, 1944) the subfamily TROMBICULINAE has been raised to the rank of a family and a new subfamily created for the divergent genus *Hemitrombicula* Ewing. These changes are noted in the revised classification that follows.

A Revised Classification of the Larvae of the Trombiculid Mites, or TROMBICULIDAE

A. Each tarsus with 2 unequal claws; pseudostigmatic organs represented by a pair of simple setae; setae on both body and appendages, simple. Known only from North America ..... HEMITROMBICULINAE Ewing
Contains but a single genus ..... *Hemitrombicula* Ewing

AA. Each tarsus 3-clawed, outer claws nearly always equal, forming a pair, middle claw usually longer than others; pseudostigmatic organs, when simple, long and more or less flagelliform ..... TROMBICULINAE Ewing

B. Body constricted near its middle; abdomen with a posterodorsal plate. Eggs laid attached to hairs of host. Known only from New Guinea and Australia ..... *Guntherana* Womersley

BB. Body not constricted near its middle; abdomen without plates. Eggs laid, as far as known, unattached to host. Known from most of the warmer regions of the world.

C. Middle tarsal claw stouter than paired claws; eyes absent
Riedlinia Oudemans

CC. Middle tarsal claw more slender than paired claws; eyes usually present.

D. Dorsal plate of cephalothorax with a single median seta on or near its anterior margin.

E. Pseudostigmatic organs strongly clavate or capitate.

F. Anterolateral setae of dorsal plate large, barbed, similar to posterolateral setae.

G. Each chelicera with a row of dorsal teeth; palpal claw usually with 2 prongs
Schöngastia Oudemans

GG. Each chelicera with only a single dorsal tooth.

H. Palpal claw undivided, or with 2–3 prongs.

I. Dorsal plate with a distinct crest in front of pseudostigmata and its posterior half with circular striations
Paraschöngastia Womersley

II. Without these characters
Neoschöngastia Ewing

HH. Palpal claw with 5–7 prongs, the accessory prongs being in 2 or 3 pairs; dorsal tooth of chelicerae vestigial or absent
Euschöngastia Ewing

FF. Anterolateral setae of dorsal plate minute, simple. Parasitic on bats ..... *Doloisia* Oudemans

EE. Pseudostigmatic organs setiform or flagelliform, and usually with barbs or lateral branches.

F. Each chelicera with a row of dorsal teeth; ventral tooth sometimes absent.

G. More than 3 subequal dorsal teeth on each chelicera; dorsal plate well developed; median seta barbed ..... *Odontacarus* Ewing

GG. Three unequal dorsal teeth on each chelicera; dorsal plate vestigial; median seta simple. Living under the surface of the skin of amphibians *Endotrombicula* Ewing

FF. Each chelicera with a single dorsal tooth and usually with a ventral tooth.

G. Palpal claw simple; dorsal setae less than 22; pseudostigmata much nearer anterior margin of dorsal plate than posterior .. *Crotiscus* Ewing

GG. Palpal claw divided into 2 or 3 prongs; dorsal setae 22 or more; pseudostigmata usually about equal distance between anterior and posterior margins of dorsal plate or nearer posterior margin.

H. Palpal claw typically divided into 3 prongs; dorsal abdominal setae usually more than 30 ..... *Trombicula* Berlese

HH. Palpal claw divided into 2 prongs, which usually are in the same horizontal plane in mounted specimens.

I. Setae on dorsal plate, exclusive of pseudostigmatic organs, 9 *Heaslipia* Ewing

II. Setae on dorsal plate, exclusive of pseudostigmatic organs, 5.

J. Anterolateral setae of dorsal plate setiform, similar to posterolaterals.

K. Dorsal abdominal setae 22 (counting posterior marginal pair) and in unengorged larva with the following arrangement, 2–6–6–4–2–2; ventral body setae 14, 1 pair being postanal *Eutrombicula* Ewing

KK. Dorsal abdominal setae over 22 (counting posterior marginal pair); ventral body setae more than 14,

more than 1 pair being postanal

Acariscus Ewing

JJ. Anterolateral setae of dorsal plate short, very stout, peglike

Fonsecia Radford

DD. Dorsal plate of cephalothorax without a median seta on or near its anterior margin but sometimes with a pair of submedian setae.

E. Dorsal plate with a pair of submedian setae on or near anterior margin.

F. Dorsal plate with an anterior median process but without crista.

G. Posterolateral setae present on dorsal plate.

H. Posterolateral setae of dorsal plate not swollen or clavate, but similar in form to anterolateral setae; dorsum of abdomen thickly beset with setae not situated on tubercles.

I. Chelicera with but a single tooth on upper margin; either first or second palpal seta barbed

Comatacarus Ewing

II. Chelicera with a row of teeth on upper margin; both first and second palpal setae simple

Acomatacarus Ewing

HH. Posterolateral setae clavate, thus differing in form from anterolateral setae; dorsum of abdomen sparsely clothed with stout setae situated on tubercles

Leeuwenhoekia Oudemans

GG. Posterolateral setae absent from dorsal plate

Apolonia Torres and Braga

FF. Dorsal plate without anterior median process but frequently with crista; each chelicera obliquely flattened at distal end, forming a "spearhead" with teeth on its lateral margin.

G. Dorsal plate subrectangular, with only simple setae; submedian setae situated on an allantoid thickening; outer tarsal claws but slightly, if any, stouter than middle claw

Whartonia Ewing

GG. Dorsal plate not subrectangular, with barbed or branched setae; submedian setae not situated on any thickening; outer tarsal claws usually much stouter than middle claw

Hannemania Oudemans

EE. Dorsal plate without a pair of submedian setae.
F. All setae on dorsal plate (exclusive of pseudostigmatic organs) marginal.
G. Dorsal plate with 4 or more pairs of lateral setae ..... *Gahrliepia* Oudemans
GG. Dorsal plate with less than 4 pairs of lateral setae.
H. Dorsal plate with 3 pairs of lateral setae; eyes present ..... *Schöngastiella* Hirst
HH. Dorsal plate with 2 pairs of lateral setae; eyes absent ..... *Walchia* Ewing
FF. Some of setae on dorsal plate not marginal; eyes usually present ..... *Gateria* Ewing

DISTRIBUTION

Trombiculid mites are found in greatest abundance and diversity in areas with a hot, moist climate and an abundance of vertebrate life. They are reported from all the zoögeographical regions of the world and parasitize, in their larval stage, representatives of four of the five classes of vertebrates, the amphibians, the reptiles, the birds, and the mammals. In the tropics they extend vertically to the tops of many mountains, yet in the arctic regions they appear to be unknown. The distribution of each of the four best known species is here considered in some detail.

The Distribution of the Common North American Chigger Mite, Eutrombicula alfreddugèsi (*Oudemans*)

Eutrombicula alfreddugèsi has an almost continuous distribution, except for certain areas made artificial by man, over all the Southern States except for the northwestern part of Texas, and in addition over the Coastal Plain and Piedmont districts of the North Atlantic States and the southern half of the Upper Austral life zone of Merriam, in the Mississippi Valley. Outside this area it occurs in many areas (Fig. 6, dotted) where there exist widely scattered local "ecological islands" in which conditions are particularly favorable for it.

Some significant records indicating the limits of distribution of *Eutrombicula alfreddugèsi* (Oudemans): The following records of *E. alfreddugèsi,* except for the 2 from Mexico, are here published for the first time. The specimens upon which they are based have all been identified by the writer, except those from Mexico which were identified by Islas (1943).

Arizona: Winslow, on hen, August 27, 1919. *Bahama Islands:* On "lizard," July 25, 1930. *California:* Coachella, on road runner, *Geococcyx californianus,* October 12, 1931, and Nice, on "common brown lizard," November 7, 1939. *Cuba:* Cabo Cruz, on black and white warbler, *Mniotilta varia,* August 31, 1930. *Delaware:* Newark, on meadow mouse, *Microtus pennsylvanicus,* August 10, 1939. *Haiti:* San Michel, on "lizard," March 23, 1925. *Illinois:* Yorkville, on "pheasant," July 19, 1941. *Kansas:* Winfield, on "collared lizard," July 27, 1942. *Mexico:* Puebla State; Matamoros and Acatlan, on man (reported by Islas, 1943). *Michigan:* Camp Bryan, on pilot black snake, *Elaphe obsoleta,* July 1931. *Minnesota:* Minneapolis, on spreading adder, *Heterodon contortrix,* July 1922. *Ohio:* Nile

FIG. 6. The geographical distribution of four species of trombiculid mites, *Eutrombicula alfreddugèsi* (Oudemans), *Trombicula autumnalis* (Shaw), *T. akamushi* (Brumpt), and *T. deliensis* Walch. Black indicates approximate area of maximum or near maximum abundance; stippling, the approximate area with scattered "ecological islands" of mites. (Original.)

township, on rabbit, *Sylvilagus floridanus,* July 29, 1937. *Panama:* Aguas Buenas, on a snake, *Spilotes pullatus,* March 31, 1931; Gatun Lake, Canal Zone, on eastern green heron, *Butorides virescens virescens,* June 5, 1931; Parito, on coati, *Nasua narica panamensis,* July 8, 1931. *Pennsylvania:* Stone Valley, adults (3 males and 1 female), June 1923. *Texas:* Uvalde, on "horned toads," May 4, 1943. *Venezuela:* Chama River, on lizard, *Anadia bitaeniata,* date (?).

The Geographical Distribution of Trombicula autumnalis (*Shaw*)

André (1928a, 1930a) has summarized the distribution records for *Trombicula autumnalis* (Shaw). Some of these records, however, are based upon cases of trombiculiasis (= trombidiasis) and for that reason are not entirely reliable. This is particularly true for the records from south central Europe where trombiculiasis is sometimes caused by another species.

According to André, *Trombicula autumnalis* is widely distributed in western and central Europe. Most of André's records are for France and western Germany, and probably central, western, and southern France is the region most severely infested by this species. In England and Scotland the mite occurs sparingly. The same appears to be true of Spain and Italy.

Some significant records of the occurrence of *Trombicula autumnalis* (Shaw): The following are a few of the more significant records as mentioned by André (1930): *Denmark:* Jutland. *England:* Isle of Wight, Lincolnshire, Surrey, Wiltshire, Yorkshire. *Germany:* Meiningen (Valley of the Saale), Teplitz (Bohemia). *Scotland:* Berwick, East Lothian. *Spain:* Locality not mentioned.

The Distribution of Trombicula akamushi (*Brumpt*)

Notwithstanding the fact that more basic research has been done on the *akamushi* than on any other trombiculid mite, its geographical and its host distribution are still imperfectly known. From great areas in eastern Asia and the western Pacific, where natural conditions seem exceptionally favorable for it, no published records of its occurrence are available. Among such areas are most of the eastern part of China, the Philippines, Borneo, and most of the Celebes. As to the possible occurrence of the *akamushi* on several types of hosts, information is very scanty or wanting, particularly regarding amphibians, reptiles, and certain kinds of birds. It is believed that most of the published host and distribution records of the *akamushi* are included below. Names of authors reporting records are given in parentheses.

Published records of the occurrence of *Trombicula akamushi* (Brumpt): *Formosa:* On *Apodemus agrarius ningpoensis,* on house mouse, *Mus musculus,* on a musk shrew, *Suncus myosurus swinhoei,* on house rat, *Rattus norvegicus,* on *Rattus rattus rufescens* (Hatori); Kagi District (Zone of Mt. Ari) (Matsumoto). *Japan:* Akita Prefecture; Hondo, Echigo, on "field mice" (Hirst); Koshi District, River Shinanogawa, on "field mouse," on house rat, *Rattus rattus alexandrinus,* on house cat, *Felis domestica* (Kitashima and Miyajima); Niigata Prefecture, adults and nymphs taken (Miyajima and Okumura); Yamagata Prefecture, adults reared (Nagayo et al). *Korea:* Locality (?) (statement by Walch). *Malay States* (Selangor): Elmina, on *Rattus rattus jalorensis* (identified by H. E. Ewing); Sungei Buloh, on man, on *Rattus rattus diardii,* on *Rattus rattus jalorensis,* on *Trichys fasciolata fasciolata* (=? *Atherurus macrourus*) (Gater); *Pescadores Islands:* Boko Island, on rodents and birds.

The Distribution of Trombicula deliensis *Walch*

According to our present knowledge, *Trombicula deliensis* Walch is confined to the tropical region of southeastern Asia, the East Indies, and northern Australia. Our knowledge of its host distribution is due largely to the work of Gater (1932).

Published records of the occurrence of *Trombicula deliensis* Walch: *Australia:* Queensland, coastal strip north of Townsville, on "rats" (Heaslip). *India:* Simla Hills (in northern India) (by Mehta). *Malay States* (all records by Gater): Selangor, Sungei Buloh, on *Rattus rattus diardii* and *Rattus rattus jalorensis;* Kuala Lumpur, on "rat"; Fraser's Hill, Pahang, Raub (Pahang), Port Dickson (Negri Sembilan). The material taken at these last four localities combined were from the following hosts: Man, *Paradoxurus hermaphroditus, Rattus concolor concolor, R. edwardsi ciliatus, R. mülleri validus, R. sabanus vociferans, Rhinosciurus laticaudatus tupaioides, Sciurus prevostii humei, S. notatus miniatus, S. nigrovittatus bilimitatus, Tragulus kanchil fulviventer, Trichys fasciculata fasciculata* (= *Atherurus macrourus*), *Tupaia glis ferruginea. New Guinea* (*Territory of*): Bulolo, on brown scrub rat, *Rattus leucopus mordax,* and Brown's rat, *Rattus axulans browni* (Gunther). *Sumatra* (all records by Walch): Goenoeng Rinteh (near Deli), on man; Lampong District, on man and "rat"; Limao Moengkoer (near Deli), on man.

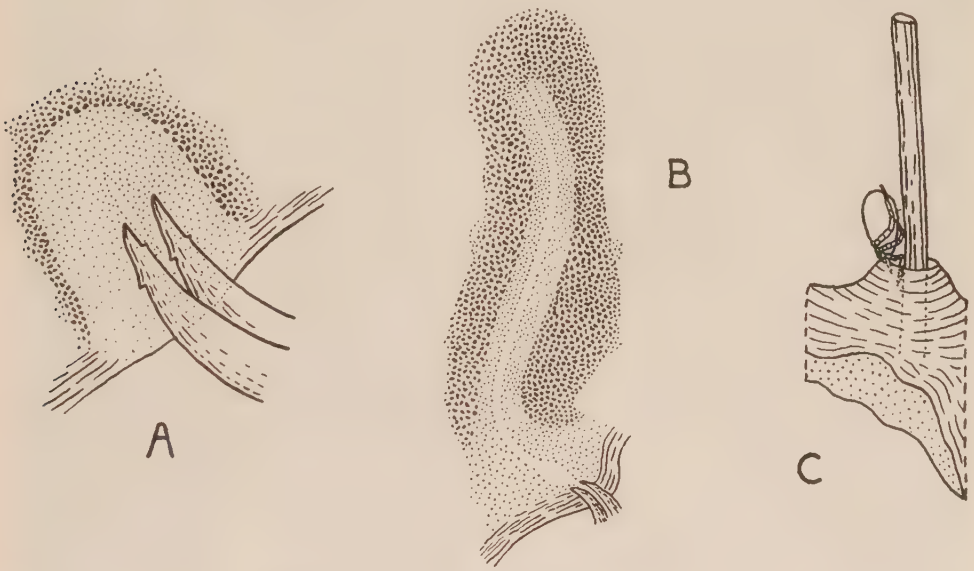


FIG. 7. At left, *A,* a longitudinal section of the "stylostome" in an early stage of development; *B,* a later stage in the formation of the same; *C,* "slice" of skin from calf of leg showing method of attachment of *Eutrombicula alfreddugèsi* in opening of a hair follicle. All much enlarged; *A,* original, *B,* after André, *C,* after Ewing.

DIRECT INJURY TO HOSTS BY TROMBICULID LARVAE

Once on a host, trombiculid larvae do not attach immediately but run about until they find a fold in the skin, a place where the clothing is tight, or some other convenient place, such as the mouth of a hair follicle, for the insertion of their chelicerae. Of 26 attached individuals observed on the writer's skin (Ewing, 1921), 5 were attached inside the rim of hair follicles. The insertion of the chelicerae usually is un-

noticed by the human host; and it is only after the injection of a digestive fluid that itching is felt. This itching usually begins 3 to 6 hours after exposure.

The injection of this fluid produces a very characteristic effect. The tissue in immediate contact with it is liquefied, and the adjoining tissue becomes toughened. As the predigested liquefied tissue (not blood) is sucked up by the mite and more digestive fluid is injected into the cavity thus produced there is formed a sclerotized tube (Fig. 7, *A* and *B*) which may be as long as the total length of the mite itself. This tube has been called the "stylostome," and at one time it was thought to be a part of the mite. Very early the tube was described by Gudden (1871), who examined human skin with attached larvae of *Trombicula autumnalis,* and noted that the tubelike structure extended into the skin from the mouth parts of the mite. This he regarded as a structure of the mite itself, in which belief he was long followed by others. In more recent years Brèthes (1909), André (1927b), Feng and Hoeppli (1933), and others have shown that this tubelike structure or canal is formed by the reaction of the tissues of the host to the digestive fluid of the mite and is in no way an organ of the latter.

The pathological changes produced in the tissues adjacent to the canal have been studied in America particularly by Toomey (1921) and by Parkhurst (1937). The latter has summarized these changes as follows:

> Between three and twenty-four hours after exposure the lesion becomes an urticarial papule and itches intensely. Generally this is the first manifestation noticed by the patient. It is often, but not invariably, follicular. In this lesion the larva, if still attached, appears near, or at, the center as a minute red dot. Within from one to three days the lesion becomes a pruritic, pale red, flat or conical papule—conical lesions often occur—and especially on the legs, thighs and lower portion of the abdomen these papules may become grossly hemorrhagic and deep purple. Some of the papules, whether hemorrhagic or not, may be surmounted by a pinhead-sized vesicle containing clear fluid. The itching is intense, generally being worse on the second or third day, and may persist after fourteen days. Owing to this the vesicle is generally scratched open and may be secondarily infected. If it is not excoriated it usually dries and is followed by scaling. Involution begins about the third day and is extremely slow. The papule shrinks, and pigmentation appears, persisting for from ten to fourteen days or longer. The lesions may be from 0.4 to 2 cm. in diameter and are sometimes larger. A lesion may last several weeks, during which time it may itch intermittently.

Secondary infection, which usually is due to scratching, may lead to a variety of conditions and may be very serious. According to Toomey (1921), in the Ozark Mountains and some other places where people go barefooted, some persons have lost toes as the result of secondary infection from chigger attacks over the toe joints.

TROMBICULIDS IN RELATION TO TSUTSUGAMUSHI DISEASE*

Tsutsugamushi disease has probably existed in eastern Asia for many centuries as has been pointed out by Sambon (1928). He found mention of a fever agreeing in many respects with this disease as occurring in southeastern China in the Chinese medical work *"Pen ts'ao Kang Mu"* compiled in the sixteenth century. But it was in Japan where the disease first gained the attention of modern medicine. Here, along the flood plains of some of the rivers in certain northwestern districts, it has existed for a long time and has been studied for over half a century. Very early some of the clinical symptoms were well established, and from the beginning many people had claimed an association between the attacks of a small reddish mite larva,

* The review here given is very brief, particularly considering the importance of the subject. For a more extensive review the recent paper by Farner and Katsampes (1944) may be consulted.

now known as *Trombicula akamushi,* and the disease. For this reason studies on the habits and the more specific relation of this mite with the disease were begun in the latter part of the last century. Along this line the work of Tanaka (1892, 1894, 1899) was outstanding. Work on the life cycle of the supposed mite transmitter soon followed and, according to Miyajima and Okumura (1917), Miyajima reared nymphs of *T. akamushi* as early as 1906 from larvae found attached to field mice. But it was several years later when Nagayo et al (1916, August) first reported the rearing of all stages of the mite. They give figures of these which show

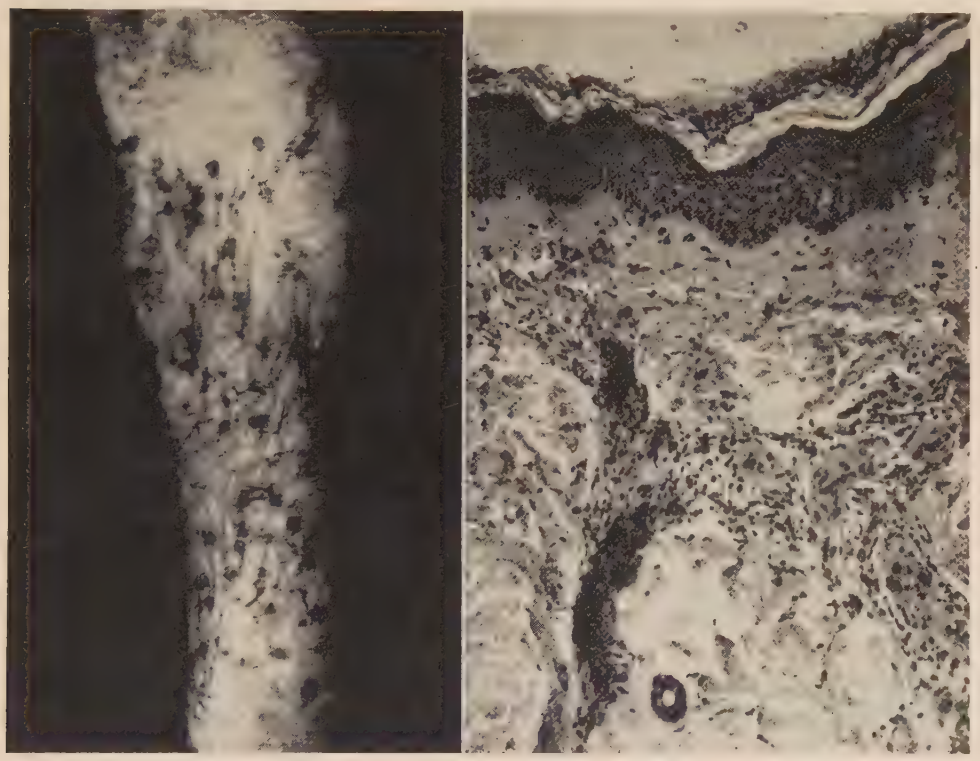


FIG. 8. Lesions produced by *Eutrombicula alfreddugèsi. To left:* Leg showing some lesions capped with the typical small vesicle; other lesions that have been excoriated by scratching (U. S. National Museum photograph). *To right:* Section from lesion on leg of man showing vascular engorgement in the middle portion of the cutis, lymphocytic perivascular infiltration and edema (after Parkhurst).

the true nymphochrysalis and also the egg. The egg, however, is photographed inside the body of the female and is very much larger in proportion to the size of the mite than the largest of the eggs shown by Kawamura and Ikeda (1936) (see Fig. 1, *a*). Independently two other groups of workers demonstrated the life cycle at about the same time, Kawamura and Yamaguchi (1916a) and Miyajima and Okumura (1917).

Hayashi (1920) was the first to describe the organism that is now regarded as the cause of tsutsugamushi disease, calling it *Theileria tsutsugamushi.* At the time he doubted its affinity with *Theileria* and suggested that further study would result in its removal from this genus. This was soon done by others.

Schüffner and Wachsmuth (1910) described a disease found at Deli, Sumatra, which was evidently very similar to tsutsugamushi disease. They called it Pseudotyphus, meaning in English pseudotyphoid fever. Later, Schüffner (1915) regarded this disease as only a variety of Japanese river fever (tsutsugamushi disease). Walch (1922) made a special study of the trombiculids attacking man in Sumatra and came to the conclusion that *Trombicula deliensis,* which he described as new, was probably the carrier of the disease which Schüffner has called pseudotyphoid fever. Walch and Keukenschrijver (1925) by means of injection of blood from a patient suffering with pseudotyphoid produced the disease in a gibbon, and by injecting an emulsion of 400 larvae of *T. deliensis* produced the disease in the same host.

Sellards (1923), apparently unacquainted with the work previously done by Hayashi (1920), obtained an organism in pure culture from animals infected with the virus of tsutsugamushi disease, which he named *Rickettsia nipponica.* Since his organism grew on an artificial medium it probably was not the same as the one described by Hayashi in 1920 as *Theileria tsutsugamushi.*

Kawamura and Imagawa (1931) found *Rickettsia* bodies in the salivary glands of a specimen of *Trombicula akamushi* taken from an infected field mouse. These they named *R. akamushi,* and claimed that the bodies were identical with those found in laboratory animals that had been injected with blood of a patient having tsutsugamushi disease. Hence they believed they had demonstrated the causative organism as well as the transmitter. Their *R. akamushi* should be regarded as a synonym of *R. tsutsugamushi* (Hayashi).

The occurrence of tsutsugamushi disease in Formosa was recognized early in the present century, and it has been studied there by several Japanese workers. Morishita (1942) states that the disease is widely distributed in the island, being found on the plains and in the mountainous regions alike. Although observed cases among the aborigines were few in number, he doubted that there was any difference in susceptibility due to race. The case mortality was found to average 12 per cent. The transmitter was said to be *Trombicula akamushi.*

In India, Boyd (1935), of the Royal Army Medical Corps, made an analysis of 110 cases of fevers of the typhus group reported for the year 1934. By means of serological tests 35 of these were placed in a "definite XK group." They corresponded closely to the Malayan scrub typhus, and apparently should be regarded as cases of tsutsugamushi disease. The vector was in no case identified. Fifteen of these 35 cases came from the Simla Hills, and a majority of them developed toward the end of the monsoon season.

Lewthwaite and Savoor (1936) studied a typhus-like disease found in the Malay States. By means of cross-immunity tests they demonstrated the close similarity of scrub typhus with the Japanese tsutsugamushi disease. Also their experiments indicated the identity of the pseudotyphoid of Sumatra and the tsutsugamushi disease of Malaya.

The form of tsutsugamushi disease known as scrub typhus in New Guinea was investigated by Gunther (1935 to 1941b), who, however, usually referred to it as endemic typhus. He made a survey of the trombiculid larvae found in the areas where the typhus was endemic, noting in particular their host relationships. Several of the mite larvae were reared either to the nymphal or adult stage, and notes on their

biology were taken. By further noting the correlation or noncorrelation of the mite attacks with the development of typhus cases, he came to the conclusion that *Trombicula minor* Berlese (here believed to be in reality *T. hirsti* Sambon) was "the likely vector" and that a bandicoot, *Echymipera cockerelli,* was "probably the effective reservoir of the disease."

A disease of the typhus group similar to scrub typhus had been noted in northern Queensland, Australia. Heaslip (1941) regarded it as tsutsugamushi disease. His experiments indicated that the bandicoot, *Isoodon torosus,* and one rat species of the genus *Melomys* and four of the genus *Mus* (*Rattus*) were probably reservoirs of the disease in nature.

Principles for the Control of Trombiculid Mites

Studies on the biology of the trombiculid mites have been sufficiently advanced at present to make it possible to summarize advantageously certain principles for their control. Those that have given success, or at least some promise of success, are here stated.

Destruction of the Mite Larvae in the Field

Applications of sulfur or sulfur ointment directly to the skin in order to kill the trombiculid larvae are old and well-known practices. Owing to the fact that trombiculiasis and itch produced by *Sarcoptes scabiei* (Degeer) were long somewhat confused, the use of sulfur ointment against the latter doubtless on occasions destroyed the trombiculid larvae also. As early as 1873 C. V. Riley reported that "in some localities, where these pests most abound, sulphur is often sprinkled, during 'jigger' season, in foot-gear as a protection." The value of sulfur in destroying attached trombiculid larvae having thus been learned, their destruction in the field by the same agent was indicated. This method has been found effective (Chittenden, 1915). For the same purpose Smith and Gouck (1944) recently have shown that dusting with 2 per cent DDT (2,2-bis(p-chlorophenyl)–1,1,1-trichloroethane) was effective. Comparing this insecticide with sulfur in effectiveness for the control of chiggers in the field, they state that DDT appeared best on the first day after application, sulfur on the seventh day, and the two equal on the third day.

Modification of Ecological Factors in the Mite Environment

Development of effective measures for controlling the trombiculids in their natural environment was long hindered because of our lack of knowlege concerning the free-living stages, and the native hosts. However, enough is now known concerning these to make possible the application of what may be termed "modification-of-environment" control. One of the ways in which the environment may be effectively modified is by destroying the growth of shrubs or larger herbaceous plants. Long ago, according to Washburn (1908), one Captain Zimmerman, who lived on an island in Lake Minnetonka, Minn., reduced the numbers of chiggers very materially by cutting out much of the underbrush and thus letting in the sunlight.

The removal of ground litter is a measure the value of which has been demonstrated. In the wooded areas near or about resort cottages along our Atlantic seaboard there are many situations where there is little brushy undergrowth, but there is a thick layer of ground litter giving good cover for trombiculids. Here the removal of this litter alone frequently is sufficient to bring about the drying of the sur-

face soil and thus the destruction of the nymphs and adults. This has been several times demonstrated along the west shore of Chesapeake Bay. As a supplementary measure it was found effective at a large Boy Scout camp (Ewing, 1927).

The use of infested fields for pasturage as a control measure is at times practical. Chittenden (1915) related that "correspondents and others" stated to him that chiggers had been destroyed in fields by turning in sheep.

Confining or removing important hosts during the active larval period of the mite's life cycle is a measure of restricted value. At one time during the development of our knowledge concerning the host relationships of *Eutrombicula alfreddugèsi* it appeared that the common box turtle, *Terrapene carolina,* was one of the very few important hosts. For this reason at the Boy Scout camp where attempts were being made to control the chiggers it was believed that if these turtles were caught and released far from camp, or placed in a pound during the active larval period, the numbers of chiggers would be greatly reduced. Accordingly (Ewing, 1927) this was done. The results were disappointing, and the practice was soon abandoned. Knowing what we now do concerning the many favored hosts of these trombiculid larvae, it is easy to understand the ineffectiveness of this plan. As a supplementary measure only, it may have had some value.

Protection of Man Against Mite Attack

Of all the measures used against trombiculid mites, those designed to protect man himself have been the most employed, and on the whole probably the most successfully. The measures come largely under three headings, the use of repellents on the skin, the impregnation of clothing with repellents, and the use of fine-mesh garments.

Some of the acaricides used to kill trombiculid larvae after they attach themselves to man have also been used as repellents. Especially is this true of sulfur and kerosene. Trombiculid larvae are very sensitive to many substances, particularly to oils, of which several kinds afford rather good protection.

Years ago, the writer (Ewing, 1925d) found that articles of clothing could be made mite-proof by impregnation with a suspension of flowers of sulfur in a strong, hot, naphtha soap solution. With this solution the following were impregnated: Wrap puttees, the legs of "coveralls," and underwear. But of particular value were impregnated "sleeves." The sleeves were made by cutting off the toe end of heavy stockings. Each of these "sleeves" was easily pulled on over the shoe into the desired position about the calf and ankle of the leg. In more recent years repellents such as dimethyl phthalate have been used effectively for treating the clothing. Concerning the use of this insecticide for treating clothing of members of our armed forces for the prevention of chigger attack, Madden, Lindquist, and Knipling (1944) state: "The most practical means of treating the clothing is to apply the liquid repellents from a small-mouth bottle in a half-inch band around the inside of the waist, the fly, and the bottoms of the legs of the trousers, the cuffs, fly, and neck of the shirt, and in a wide band around the upper part of the socks. Clothing treated in this manner with dimethyl phthalate, *Indalone,* or *Rutgers 612* gave good protection up to 30 days after treatment."

Closely woven garments will not permit the entry of trombiculid larvae through their mesh. Taking advantage of this fact, certain Japanese investigators devised

a mite-proof suit which prevents the entry of the larvae through any part of the outer clothing. Some of our so-called "coveralls" that cover the back and fit snugly about the neck can be used effectively to protect against the larvae by tying the bottom of each leg of the garment about the shoe top.

WARTIME INVESTIGATIONS OF TSUTSUGAMUSHI DISEASE IN THE SOUTH PACIFIC

When war with Japan broke out, already considerable ground work on the tsutsugamushi disease had been done in Australia and New Guinea, particularly by Heaslip (1941) and by Gunther (1935, etc). This work was now taken up by two United States agencies, one being a special Army commission, which was sent into the field by the Surgeon General of the U. S. Army, under the auspices of the United States of America Typhus Commission and the Army Epidemiological Board. The other was the Naval Medical Research Unit No. 2. The Army commission went to the South Pacific in September 1943 to study this form of tsutsugamushi disease in connection with our troop movements, and some of the early results obtained have already been published as we shall soon note. The Naval Medical Research Unit No. 2 was slowly organized in the latter part of 1943 and early in 1944 to study certain tropical diseases in the South Pacific, including tsutsugamushi disease. During the several weeks before the departure of members of its personnel the writer worked in coöperation with some of them at the United States National Museum.

During the present year a few articles have appeared dealing with tsutsugamushi disease in the South Pacific. Lipman, Byron, and Casey (1944) have reported on a clinical survey of 101 cases which they called scrub typhus that were admitted to the First Evacuation Hospital in New Guinea between February 8 and September 1, 1943. According to their report there was a case mortality rate of 7.9 per cent and an average duration of the febrile period of 17 days. It was found, however, that in 5 of the 8 fatal cases the patients also had benign tertian malaria.

Ahlm and Lipshutz (1944) soon followed with a report on about 70 cases of tsutsugamushi disease in an undisclosed (for reasons of military security) area, paying particular attention to the clinical symptoms but also noting other aspects of the disease. They found mites near sago palm swamps that were margined by kunai grass, though only occasionally could the mites be found where this grass grew tall in the natural clearings adjacent to the jungle. The authors were of the opinion that the field rat (species?) was the principal reservoir, but that other reservoirs, though of less importance, also were present. In regard to the primary lesion they state: "The most common location of the primary lesion of this disease is the scrotal area, though the inguinal and ankle areas are frequently involved." This lesion was not always produced. In fact many patients had exhibited no sign of it.

As to the seriousness of the disease Ahlm and Lipshutz state: "Malaria lends itself to treatment readily and has an exceedingly low mortality rate, with only about fourteen man days lost. Tsutsugamushi fever, on the other hand, lends itself to treatment very poorly and has a fairly high mortality rate (considering other figures), with at least one hundred man days lost."

For individual protection these authors recommend treating the lower part of the trousers with a repellent, wearing high boots or footgear, and dusting the body with a mixture of sublimed sulfur and talcum. They also state that the repellent now in use by "the U. S. Army is highly satisfactory if properly applied."

According to information prepared in the Office of the Surgeon General and U. S. A. Typhus Commission (Bul. U. S. Army Med. Dept. (76), pp. 52–61, May 1944), scrub typhus was encountered particularly in fields of kunai grass bordered by jungle along water courses, the danger of infection being greatest at the border of kunai grass and jungle.* As control measures the preparation of camp sites by the cutting and removal or burning of the kunai grass was emphasized. Sleeping on the ground should be avoided, and tents should have floors raised 2 to 3 feet from the ground. Individual protection for personnel in combat areas should be obtained by bathing with a thorough application of soap as soon as possible after exposure, and by the use of repellents.

THE DANGER OF SPREADING TSUTSUGAMUSHI DISEASE BECAUSE OF WAR CONDITIONS

There has been considerable apprehension lest because of the present World War some of the tropical diseases, such as tsutsugamushi disease, may be introduced into many other countries where they are unknown today. Yet when we consider that tsutsugamushi disease has existed in eastern Asia for centuries without becoming established elsewhere, it might appear to some that even now there is little danger of its wide dissemination. However, it is observed that a similar rickettsiosis, Rocky Mountain spotted fever, apparently has spread from a small area in our Northwest to nearly every state in the union in less than half a century.

If tsutsugamushi disease is introduced into these other countries, in what manner will this probably take place? At first thought it might appear that soldiers returning from infested areas in the Pacific would be the most probable agent of introduction. Such an introduction might be brought about in two ways, first by the soldiers bringing with them attached, live, infected mite larvae, and second, by their bringing with them the Rickettsiae in their body tissues. In order to establish the disease in a distant country in the first case the attached larvae would have to engorge successfully and then drop into a proper ecological environment for the completion of their life cycle. Introduction by this method certainly is a possibility, but it should be noted that while man is a host readily attacked by these mites, yet he does not appear to be a favored host. At least that appears to be the case with our common chigger, *Eutrombicula alfreddugèsi*. I have allowed many of the larvae of this species to attach to my skin, and although some of them did engorge to repletion, from none could a nymph be reared.

Years ago Dr. Walch told me, while he was in Washington, that to his knowledge only a single nymph of any trombiculid had ever been reared from larvae that had engorged on man. He stated that from a larva that had engorged on a native in the Dutch East Indies a nymph was obtained. I did not learn the species, and it is possible that this very important observation was never put in print. If by chance these infected larvae should engorge successfully on man and also transform into nymphs, they yet would have to be in a proper ecological environment to reach maturity and transmit their Rickettsiae to the next generation.

In the second case a larva of a species not now a transmitter would have to attach to the soldier vector returned to his native country, and not only successfully engorge upon him but also acquire his Rickettsiae and drop off in a favorable ecological environment for the completion of its life cycle.

*F. C. Bishopp, however, states that he recently observed islands adjacent to New Guinea devoid of kunai grass on which numerous cases of scrub typhus originated.

When all these various probabilities are considered, it appears that the chances are small that the disease could be widely spread by the agency of returning soldiers, either with attached, infected mite larvae or with the Rickettsiae in their bodies.

Another method of dissemination of tsutsugamushi disease might be by way of transportation of reservoir hosts other than man. Rats appear to be the most important of such hosts and their ability to spread from country to country and from continent to continent has been most convincingly demonstrated in the past.

Again a very real danger of spreading tsutsugamushi disease comes from the possibility of transporting infected mites, either in the nonparasitic stages or in the unattached parasitic stage. The nonparasitic stages are found in the surface soil. Hence, any shipment of soil from an infested area in eastern Asia or the South Pacific to countries outside these areas might contain one or more of these stages. Some of these could doubtless be transported alive and might establish themselves in a distant country under a suitable environment.

The free, unattached, parasitic larvae are resistant to heat and dryness and are very active. Their length of life unattached has not been accurately determined, but in the case of *Eutrombicula alfreddugèsi* it probably is several weeks. According to Lemaire (1867) the Mexican *tlalsahuatl,* now regarded as the same as our *Eutrombicula alfreddugèsi,* was introduced into France in 1867. The basis for his belief was the reported finding of a specimen in the eye of a girl, whose father had previously received from Mexico numerous boxes, the packing and contents of which were left for some time close to the lawn where the child played. In view of the facts that the position of the supposed attachment was unusual in this case and the specimen was lost before an identification of it could be made, this record cannot be regarded as authentic. However, a real danger exists, through shipments of various kinds, of introducing disease-infected trombiculids into distant countries.

PRESENT AND FUTURE PROBLEMS

Perhaps it would be fitting to end this discussion of the trombiculid mites and their relation to disease by pointing out some of the more important considerations relating to them that should require our immediate or future attention.

1. Doubtless of most immediate concern is the possibility of reducing the danger of disseminating tsutsugamushi disease because of the present war conditions. Although much more could be known concerning the biology and distribution of the mite vectors and the disease itself, enough is known to indicate that the prevention of widespread dissemination of this disease may be a difficult matter under World War conditions. Further study, however, may indicate some practical measure to be taken in the very near future to reduce the danger of spreading this serious malady.

2. In the line of investigation much attention should be given to the rôle of birds, particularly in regard to their dissemination of the mite agents and acting as natural reservoirs for the disease.

3. The need for a thorough morphological study of at least one economically important species of the TROMBICULIDAE is apparent. This should include the histology of the internal organs and should throw much light on the structure and function of the mechanism for secreting the extraintestinal digestive fluid. Also the reproductive system, which is known to be basically different from that of the harvest

mites proper, should be studied and described. Finally such a study might elucidate the manner in which the Rickettsiae are transmitted from the mother, through the egg, to the next generation of trombiculids.

4. The food habits of the nymphs and adults of all species should be investigated. Very little is known about those of any species.

5. The responses of the better-known trombiculid species to light, heat, moisture, and other elements of their ecological environment should be studied. This would give us a much sounder basis for developing certain types of control measures.

6. Finally, the whole problem of speciation in the trombiculids, from both a theoretical and a practical standpoint, should be undertaken by one or more investigators on a long-time basis, noting particularly the effects of hosts and geographical distribution.

Bibliography

(In this bibliography references dealing with the biology, taxonomy, or distribution of the trombiculid species known to attack man are fairly complete. Of those dealing with the clinical aspects of tsutsugamushi disease or the control of the trombiculid mites only a selected few of the more important ones are given.)

Ahlm, C. E. and Lipshutz, J. 1944 Tsutsugamushi Fever in the Southwest Pacific Theater. J. Am. Med. Assn. **124**: 1095–1100, illus.

Altamirano, F. 1892 El Tlalzahuate. Estudio (Organo del "Instituto Medico Nacional" de Mexico) **4**: 196–198.

André, M. 1926a Notes complémentaires et synonymiques concernant divers Thrombidiidae. Bull. Mus. Nat. Hist. Nat. Paris **32**: 375–377.

———1926b Les Thrombidiidae de la faune française. Bull. Soc. Zool. Paris **51**: 175–228.

———1927a Sur quelques noveaux cas d'observation du *Leptus autumnalis* Shaw. Bull. Soc. Zool. France **52**: 313–319, illus.

———1927b Digestion "extra-intestinale" chez le Rouget. Bull. Mus. Nat. Hist. Nat. Paris **33**: 509–516, illus.

———1927c Observations biologiques sur la larve du *Thrombicula autumnalis* Shaw. Bull. Soc. Zool. France **53**: 368–370.

———1928a La répartition géographique du rouget en Europe. Compt. Rend. Assn. France Adv. Sc. **52**: 638–640.

———1928b Recherches sur le développement postlarvaire du rouget (*Leptus autumnalis* Shaw). Compt. Rend. Assn. France Adv. Sc. **187**: 842–844, illus.

———1929a Une forme adult de rouget. Compt. Rend. Assn. France Adv. Sci. **189**: 545–546, illus.

———1929b Description d'une forme adulte du rouget. Bull. Mus. Nat. Hist. Nat. Paris (2 ser.) **1**: 394–400, illus.

———1929c Les pièces buccales de la nymphe du *Thrombicula autumnalis* Shaw. Bull. Soc. Zool. France **54**: 484–489, illus.

———1930a Contribution a l'étude d'un acarien: le *Thrombicula autumnalis* Shaw. Mém. Soc. Zool. France **29**: 39–138, illus.

———1930b Sur une larve d'acarien parasite de l'homme et des animaux en Uruguay, appartenant au genre *Thrombicula* Berlese. Ann. Parasitol. **8**: 355–361, illus.

———1937a Note sur différents *Thrombicula* adultes trouvés en France avec description d'une espèce nouvelle. Bull. Mus. Nat. Hist. Nat. Paris (2 ser.) **9**: 313–318, illus.

———1937b Sur l'apparition brusque des acutats ou rougets. Bull. Mus. Nat. Hist. Nat. Paris (2 ser.) **9**: 379–383.

———1938 Quelques observations sur la larve du *Thrombicula autumnalis* Shaw à l'état de vie libre. Bull. Soc. Zool. France **63**: 45–47.

Annand, P. N. and others. 1944 Tests conducted by the Bureau of Entomology and Plant Quarantine to appraise the usefulness of DDT as an insecticide. J. Econ. Entom. **37**: 125–159.

Baker, A. C. 1943 The typical epidemic series. Am. J. Trop. Med. **23**: 559–566.

Berlese, A. 1888 Acari Austro-Americana. Bull. Entom. Soc. Italiana **20**: 171–222, illus.

———1905 Acari Nuovi. Manipulus IV. (Acari di Giava.) Redia **2**: 154–176, illus.

———1912 Trombidiidae. Redia **8**: 1–291, illus.

Boshell, J. and Kerr, J. A. 1942 Veinticinco especies nuevas de Trombidiideos de Colombia. Rev. Acad. Colombiana Cien. Exact., Fisico-Quim. y Nat. **5**: 1–38, illus.

Boyd, J. S. K. 1935 Fevers of the typhus group in India: An analysis of 110 cases reported in 1934, J. Roy. Army Med. Corps **65**: 289–305, 361–367.

Brèthes, J. 1909 El "Bicho Colorado." An. Mus. Nac. Buenos Aaires **12**(ser. 3): 211–217, illus.

Bruyant, L. 1910 Description d'une nouvelle larve de Trombidion (*Paratrombium egregium*, n. gen., n. sp.), et remarques sur les Leptes. Zool. Anz. **35**: 347–352.

Chittenden, F. H. 1915 Harvest mites, or "chiggers." U. S. Dept. Agr., Farm. Bull. 671: 1–7, illus.

Dugès, A. 1892 El tlalzahuatl. Estudio (Organo del "Instituto Medico Nacional" de Mexico) **4**: 198–199, illus.

Esaki, T. 1939 Arthropods injurious to man in mandated South Sea Islands of Japan. (Report I.) Volume Jubilaire en l'honneur du Profess. J. Yoshida **1**: 230–252, Osaka, Osaka Nat. Hist. Soc.

Ewing, H. E. 1920 The genus *Trombicula* Berlese in America and the Orient. Ann. Entom. Soc. Am. **13**: 381–390, illus.

———1921 Studies on the biology and control of chiggers. U. S. Dept. Agr. Bull. 986: 1–19, illus.

———1924 Our only common North American chigger, its distribution and nomenclature. J. Agr. Res., U. S. Dept. Agr. **26**: 401–403.

———1925a The adult of our common North American chigger. Proc. Biol. Soc. Washington **38**: 17–20, illus.

———1925b A new chigger (*Trombicula* larva) from Brazil. Proc. Entom. Soc. Washington **27**: 91–92.

———1925c A contribution to our knowledge of the taxonomy of chiggers. Including the descriptions of a new genus, six new species and a new variety. Am. J. Trop. Med. **5**: 251–265, illus.

———1925d Sulphur-impregnated clothing to protect against chiggers. J. Econ. Entom. **18**: 827–829, illus.

———1926a The common box-turtle, a natural host for chiggers. Proc. Biol. Soc. Washington **39**: 19–20.

———1926b Key to the known adult Trombiculas (adults of chiggers) of the New World with descriptions of two new species. Entom. News **37**: 111–113.

———1926c The life history and biology of the tree-toad chigger, *Trombicula hylae* Ewing. Ann. Entom. Soc. Am. **29**: 261–267, illus.

———1927 Recent developments in regard to the control of chiggers. J. Washington Acad. Sc. **17**: 182.

———1928 A preliminary key to the larvae of fifteen species of the mite genus *Trombicula*, with descriptions of four new species. Proc. Entom. Soc. Washington **30**: 77–80.

———1929a Birds as hosts for the common chigger. Am. Nat. **63**: 94–96.

———1929b A manual of external parasites, 225 pp., 96 figs. Charles C Thomas, Publisher, Springfield, Illinois.

———1931 A catalogue of the Trombiculinae, or chigger mites of the New World with new genera and species and a key to the genera. Proc. U. S. Nat. Mus. **80**(8): 1–19, illus.

———1933 Three new chigger mites of the genus *Trombicula* from Panama, with a key to the known adults of *Trombicula* of the New World. Proc. U. S. Nat. Mus. **82**(29): 1–6, illus.

———1937 New species of mites of the subfamily Trombiculinae, with a key to the New World larvae of the akamushi group of the genus *Trombicula*. Proc. Biol. Soc. Washington **50**: 167–174.

———1938a The scientific name of the common North American chigger preoccupied. Proc. Helm. Soc. Washington **5**: 26–27.

———1938b A key to the genera of chiggers (mite larvae of the subfamily Trombiculinae) with descriptions of new genera and species. J. Washington Acad. Sc. **27**: 288–295, illus.

———1942 Remarks on the taxonomy of some American chiggers (Trombiculinae), including the descriptions of new genera and species. J. Parasitol. **28**: 485–493, illus.

———1943 The American chiggers (larvae of the Trombiculinae) of the genus *Acariscus*, new genus. Proc. Entom. Soc. Washington **45**: 57–66, illus.

———1944 Notes on the taxonomy of the trombiculid mites. Proc. Biol. Soc. Washington **57**: 101–104.

Farner, D. S. 1944 Arthropod-borne diseases in Micronesia. U. S. Naval Med. Bull. **42**: 977–989, illus.

Farner, D. S. and Katsampes, C. P. 1944 Tsutsugamushi disease. U. S. Naval Med. Bull. **43**: 800–836, illus.

Feng, L. C. and Hoeppli, R. 1933 On some histological changes caused by mites. China Med. J. **47**: 1191–1199, illus.

DA FONSECA, F. 1936 Notas de acareologia. XXIII. Novas especies de Trombiculinae dos generos *Trombicula, Hannemania* e *Neoschöngastia.* Mem. Inst. Butantan **10**: 47–50, illus.

GATER, B. A. R. 1932 Malayan trombidiid larvae, Part I. Parasitology **24**: 143–174, illus.

GUDDEN, B. A. VON 1871 Ueber eine Invasion von *Leptus autumnalis.* Arch. path. Anat., **52** [5 Fol., **2**]: (2), 255–259, illus.

GUNTHER, C. E. M. 1935 Endemic typhus in New Guinea. Med. J. Australia **1**: 813–814.

———1937 The serology of sixteen cases of endemic typhus in New Guinea. Med. J. Australia **1**: 439–440.

———1938 The probable vector of endemic typhus in New Guinea. Med. J. Australia **2**: 202–204.

———1939a Trombidiid larvae in New Guinea. Proc. Linn. Soc. N. S. Wales **64**: 281–282, illus.

———1939b The association between the larva described as *Trombicula hirsti* var. *buloloensis* Gunther 1939, and *Trombicula minor* Berlese 1904. Proc. Linn. Soc. N. S. Wales **64**: 285–286, illus.

———1940a Further observations on the trombidiid larvae of New Guinea. Proc. Linn. Soc. N. S. Wales **65**: 250–258, illus.

———1940b Notes on the synonyms of *Trombicula minor* Berlese 1904. Proc. Linn. Soc. N. S. Wales **65**: 477–478.

———1940c Four larval Trombidiidae from British North Borneo. Proc. Linn. Soc. N. S. Wales **65**: 479–483, illus.

———1940d A survey of endemic typhus in New Guinea. Med. J. Australia **2**: 564–573.

———1941a Two new Trombidiid larvae from New Guinea. Proc. Linn. Soc. N. S. Wales **66**: 157–159, illus.

———1941b Studies in Trombidiidae. Proc. Linn. Soc. N. S. Wales **66**: 391–395.

HATORI, J. 1919 On the endemic tsutsugamushi disease of Formosa. Ann. Trop. Med. and Parasitol. **13**: 233–258, illus.

HAYASHI, N. 1920 Etiology of tsutsugamushi disease. J. Parasitol. **7**: 53–68, illus.

HEASLIP, W. G. 1941 Tsutsugamushi fever in north Queensland, Australia. Med. J. Australia **1**: 380–392.

HIRST, S. 1915a On the "Harvest Bug" (*Microtrombidium autumnalis* Shaw). J. Econ. Biol. **10**: 73–77, illus.

———1915b On the tsutsugamushi (*Microtrombidium akamushi* Brumpt) :—Carrier of Japanese river fever. J. Econ. Biol. **10**: 79–82 illus.

———1921 On three new parasitic mites. Ann. and Mag. Nat. Hist. **7** (ser. 9) : 37–39.

———1925 On a harvest bug (*Leeuwenhoekia australiensis,* sp. n.) attacking human beings at Sydney, New South Wales. Tr. Roy. Soc. Trop. Med. and Hyg. **19**: 150–152, illus.

———1926 On the nymphal form of the harvest bug (*Trombicula* (*Neotrombicula*) *autumnalis* Shaw). Ann. Appl. Biol. **13**: 140–143, illus.

———1929a Note on the "Tea-tree Ich-mite" (*Trombicula hirsti* Sambon = *T. pseudo-akamushi* Hatori?). Ann. and Mag. Nat. Hist. **3** (10 ser.) : 564–565.

———1929b On the larval trombidiid mite (*Trombicula hirsti* Sambon) that causes the "Scrub-Itch" of Northern Queensland and the Coorong, South Australia. Tr. Roy. Soc. So. Australia **53**: 24–26.

HOWARD, C. W. 1918 A preliminary report on the Trombidiidae of Minnesota. Seventeenth Rep. State Entom. Minnesota **17**: 111–144, illus.

ISEKI, K. 1933 Untersuchung über die akute juckende Dermatitis, hervorgerufen durch "Karasus." Acta Dermat. **21**: 178–179.

ISLAS, F. 1943 Observaciones sobre el tlalzahuate en Izucar de Matamoros y Acatlan, Puebla. An. Inst. Biol. Mex. **14**: 439–450, illus.

JACOT, A. P. 1938 Thomas Say's free-living mites rediscovered. Psyche **45**: 121–132, illus.

KAWAMURA, R. 1926 Studies on tsutsugamushi-disease. Med. Bull. Coll. Med. Univ. Cincinnati.

KAWAMURA, R. AND IKEDA, K. 1936 Ecological study of the tsutsugamushi, *Trombicula akamushi* (Brumpt). Zool. Mag. Tokyo **48**: 553–563.

KAWAMURA, R. AND IMAGAWA, Y. 1931 Die Festellung des Erregers bei der Tsutsugamushikrankheit. Zentralbl. Bakteriol. (Abt. 1) **122**: 253–261, illus.

KAWAMURA, R. AND YAMAGUCHI, 1916a Ueber Imago und Nymphe der Akamushi. Tokyo Iji-shinshi Nr. 1989. (Cited by Kitashima and Miyajima, 1918.)

———1916b Ueber den anatomischen Bau der Imago der Akamushi und ihren Entwicklungscyklus. Hokuetsu Igakkai Zasshi **11** (5). (Cited by Kitashima and Miyajima, 1918.)

KITASHIMA, T. AND MIYAJIMA, M. 1918 Studien ueber die Tsutsugamushi-krankheit. Kitasato Arch. Exper. Med. **2**: 91–146, 147–244, illus.

LEMAIRE, M. J. 1867 Importation en France du Tlalsahuate. Compt. Rend. Acad. Sc., Paris **65**: 215–216.

LEWTHWAITE, R. AND SAVOOR, S. R. 1936 Typhus group of diseases in Malaya: Relation of rural typhus to tsutsugamushi disease with special reference to cross-immunization tests. Brit. J. Exper. Path. **17**: 448–460.

LINNAEUS, C. 1758 Systema Naturae (10th ed.), Genus 235, Species 22.

LIPMAN, B. L., BYRON, R. A. AND CASEY, A. V. 1944 Clinical survey of scrub typhus fever. Bull. U. S. Army Med. Dept. (72): 63–70.

MADDEN, A. H. LINQUIST, A. W. and KNIPLING, E. F. 1944 Tests of repellents against chiggers. J. Econ. Entom. **37**: 283–286.

MATASUNAGA, T. 1927 Über die sogen. "Shin"-Hautkrankheit auf den Koralleninseln der Südsee und ihren Erreger. Acta Dermat. **10**: 45–59. (Cited by Farner, 1944.)

MATSUMOTO, S. 1935 Tropische Krankheiten in Japan und den umleigenden Gebieten. Acta Dermat. **26**: 6–33. (Cited by Farner, 1944.)

MEHTA, D. R. 1937 Studies on typhus in the Simla Hills. Pt. VIII. Indian J. Med. Res. **25**: 353.

MELVIN, R., SMITH, C. L. AND GRAHAM, O. H. 1943 Some observations on chiggers. J. Econ. Entom. **36**: 940.

METHLAGL, A. 1927 Über die Trombidiose in den österreichischen Alpenländern. Dkschr. Mathem. Naturw. **101**: 213–250.

MILLER, A. E. 1925a The native host of the chigger. Science 61: 345–346.

————1925b An introductory study of the Acarina, or mites, of Ohio. Bull. Ohio Agr. Exper. Sta. (386): 85–172, illus.

MIYAJIMA, M. AND OKUMURA, T. 1917 On the life cycle of the "Akamushi," carrier of Nippon river fever. Kitasato Arch. Exper. Med. **1**: 1–14, illus.

MORISHITA, K. 1942 Tsutsugamushi disease: Its epidemiology in Formosa. Proc. Sixth Pacific Sc. Cong. **5**: 639–647.

MUMFORD, E. P. AND MOHR, J. L. 1943 Background to post-war reconstruction. Part I. Preliminary report on parasitic and other infectious diseases of the Japanese mandated islands and Guam. Am. J. Trop. Med. **23**: 381–400.

————1944 Manual on the distribution of communicable diseases and their vectors in the tropics Pacific islands section—Part I. Am. J. Trop. Med. **24**(3), sup: 1–26.

MURRAY, A. 1877 Economic entomology. Aptera. So. Kensington Sc. Handb. I–XXIII, 1–433, illus.

NAGAYO, M., MIYAGAWA, Y., MITAMURA, T. AND IMAMURA, A. 1916 Ueber die Imago und die Eier von Tsutsugamushi. Iji-shimbun Nr. 943. (Cited by Kitashima and Miyajima, 1918.)

————1916 Ueber die Imago und die beweglichen Pupen von Tsutsugamushi (Akamushi). Iji-shimbun Nr. 956: 1081–1096, illus.

————1917 Ueber die zoologische Stellung der Akamushi. Eiseigaku Densenbyōgaku Zasshi **13**(2). (Cited by Kitashima and Miyajima, 1918.)

OUDEMANS, A. C. 1902 Acarologische aanteekeningen. Entom. Ber. **1**: 43–45.

————1903 Notes on acari. Fifth series. Tijdschr. Entom. **45**: 123–150, illus.

————1905 Acarologische aanteekeningen XVI. Entom. Ber. **1**: 216–218.

————1906 Acari. Nova Guinea. Résultats de l'expédition scientifique Neerlandaise à la Nouvelle-Guinée **5**(Zool.): 101–161.

————1908 Roode boschijt van Nieuw Guinea. Tijdschr. Entom. **51**: 25–27.

————1909 Über die bis jetzt genauer bekannten Thrombidium-larven und über eine neue klassifikation der Prostigmata. Tijdschr. Entom. **52**: 19–61, illus.

————1910a Acarologische aanteekeningen XXXIII. Entom. Ber. **3**: 83–90.

————1910b Acarologische aanteekeningen XXXIV. Entom. Ber. **3**: 103–109.

————1911a Acarologische aanteekeningen XXXV. Entom. Ber. **3**: 118–126.

————1911b Acarologische aanteekeningen XXXVI. Entom. Ber. **3**: 137–139.

————1912 Die bis jetzt bekannten Larven von Thrombidiidae und Erythraeidae. Zool. Jahrb., Sup. **14**(1): 1–230, illus.

————1916 Notizen über acari. 24 Reihe. Tijdschr. Entom. **59**: 18–54, illus.

————1927 Verslag 82 ste vergadering der Ned. Entom. Ver. 28 Mei 1927. Tijdschr. Entom. **70**: 72.

————1937 Kritisch historisch overzicht der acarologie, III, D, p. 1363.

————1938 Nieuwe vondsten op het gebied der systematiek en der nomenclatuur der acari. Tijdschr. Entom. **81**(vers. II): 1–10.

————1939 Neue Funde auf dem Gebiete der Systematik und der Nomenklatur der Acari. Vi. Zool. Anz. **127**: 75–80.

PARKHURST, H. J. 1937 Trombidiosis (infection with chiggers). Arch. Dermat. and Syph. **35**: 1011–1034, illus.

PICARD, F. 1927 Sur la forme adulte du *Leptus autumnalis*. Bull. Soc. Zool. France **1927**: 189–193.

RADFORD, C. D. 1942 The larval Trombiculinae (Acarina, Trombidiidae) with descriptions of twelve new species. Parasitology **34**: 55–81, illus.

RIBEYRO, R. E. AND BAMBARÉN, C. A. 1922 El Leptus Japa de las montanas del Peru. Arch. Asoc. Peruana Prog. Cien. **2**: 113–116, illus.

RILEY, C. V. 1873 Harvest mites. Am. Nat. **7**: 16–19, illus.

SAMBON, L. W. 1927 The "Scrub Itch-Mite" of North Queensland: a new species of *Trombicula*. Ann. and Mag. Nat. Hist. **20**(9 ser.): 157–161, illus.

———1928 The parasitic acarians of animals and the part they play in the causation of the eruptive fevers and other diseases of man. Ann. Trop. Med. and Parasitol. **22**: 67–132, illus.

SCHIERBEEK, R. 1937 *Trombicula vanommereni* n. sp. rouget nouveau de la Guyane Néerlandaise. Ann. Parasitol. **15**: 326–329, illus.

SCHÜFFNER, W. 1915 Pseudotyphoid fever in Deli, Sumatra. Philippine J. Sc. **10**: 345–353.

SCHÜFFNER, W. AND WACHSMUTH, MARGARETHE 1910 Über eine typhusaritige Erkrankung Pseudotyphus von Deli. Ztschr. Klin. Med. **71**(1–2): 133–156.

SELLARDS, A. W. 1923 Cultivation of a Rickettsia-like microorganism from tsutsugamushi disease. Am. J. Trop. Med. **3**: 529–546.

SMITH, C. N. AND GOUCK, H. K. 1944 DDT, sulfur, and other insecticides for the control of chiggers. J. Econ. Entom. **37**: 131–132.

TANAKA, K. 1892 Erster Bericht über das Grundwessen des japanischen Ueberschwemmungsfiebers. Ztschr. Tokio Med. Gesellsch. **6**: (21) 35–36; (22) 53–56; (23) 17–21.

———1894 Zweiter Bericht über die Aetiologie der Kedanikrankheit. Ztschr. Tokio Med. Gesellsch. **8**: (Cited by Tanaka, 1899.)

———1899 Ueber Aetiologie und Pathogenese der Kedani-Krankheit. Centralbl. Bakteriol. (Abt. 1) **26**: 432–439.

TEODORO, G. 1918 Il ciclo di sviluppo dell' *akamushi* secondo le recenti ricerche dei giapponesi Miyajima e Okumura. Redia **13**: 105–114.

VAN THIEL, P. H. 1930a *Trombicula flui* n. sp., a patatta-mite ("Patatta-Luis") of Surinam. Parasitology **22**: 346–354, illus.

———1930b De "Patatta-luis" uit Suriname, met aanteekeningen omtrent de aetiologie der Leishmaniosis americana. Geneesk. Tijdschr. v. Nederl.-Ind. **70**: 47–63, illus.

TOOMEY, N. 1921 Trombidiasis. Urol. and Cutan. Rev. **25**: 598–608, illus.

TORRES, S. AND BRAGA, W. 1939 *Apolonia tigipioénsis*, g. et sp. n. (Trombiculinae) Parasito de *Gallus gallus* dom. Bol. Soc. Brasileire Med. Vét. An. **9**: 1–7, illus.

TRÄGÅRDH, I. 1905 Acariden aus Ägypten und dem Sudan. Swed. Zool. Exped. to Egypt and White Nile 1901 Pt. 2: 1–124, illus.

TROUESSART, E. L. 1899 Sur la piqure du rouget. Arch. Parasitol. **11**: 286–290.

VITZTHUM, H. GRAF 1929 Systematische Betrachtungen zur Frage der Trombidiose. Z. Parasitenk. **2**: 223–247.

WALCH, E. W. 1922 Over *T. deliensis*, vermoedelijk over brengster der pseudo-typhus, en andere Delische Trombicula. Geneesk. Tijdschr. voor Ned.-Indië. 62: 530–588. English version: Kitasato Arch. Exp. Med. **5**: 63–83, illus.

———1924 Over Trombiculae, welke de pseudotyphus overbrengen, en na verwante mijten uit Deli. Geneesk. Tijdschr. voor Ned.-Indië **64**: 1–33, illus.

———1925 On the Trombiculae, carriers of pseudo-typhus, and related species from Sumatra. Kitasato Arch. Exp. Med. **6**: 235–257, illus.

———1927 Nederlandsch-Indische Trombiculae en verwante mijten, soorten uit de Lampongsche Districten en de Omgeving van Makassar. Geneesk. Tijdschr. Ned.-Indië **67**: 922–933, illus.

WALCH, E. W. AND KEUKENSCHRIJVER, N. C. 1925 Über die Epidemiologie des Pseudotyphus von Deli. Arch. Schiffs-u. Tropen-Hyg. (supp. 1) **29**: 420–428, illus.

WASHBURN, F. L. 1908 The irritating harvest mite or "Jigger." Twelfth Rep. State Entom. Minnesota: 156–158, illus.

WENDLAND, DR. 1912 Bericht über einige an Bord der von Ponape zurückgekehrten Kriegsschiffe aufgetretene Erkrankungen von Typhus exanthematicus (Flecktyphus). Arch. Schiffs-u. Tropen-Hyg. **16**: 33–34.

WHARTON, G. W. 1938 Acarina of Yucatan caves. Carnegie Inst. Washington Pub. 491: 137–152.

WILLMANN, C. 1940 *Trombicula minor* Berl. 1905, Typenart der gattung *Trombicula* Berlese. Zool. Anz. **133**: 131–136.

WOMERSLEY, H. 1934 A revision of the trombid and erythraeid mites of Australia with descriptions of new genera and species. Rec. So. Australia Mus. 5: 179–254.

———1936 Additions to the trombidiid and erythraeid acarine fauna of Australia and New Zealand. J. Linnean Soc. London **40**: 107–121.

———1937 A revision of the Australian Trombidiidae. Rec. So. Australia Mus. **6**: 74–100, illus.

———1939 Further notes on the Australian Trombidiidae with descriptions of new species. Trans. Roy. Soc. So. Australia *63*: 149–166, illus.

WOMERSLEY, H. AND HEASLIP, W. G. 1943 The Trombiculinae (Acarina) or itch-mites of the Austro-Malayan and Oriental Regions. Trans. Roy. Soc. So. Australia **67**: 68-142, illus.

A NEW MOUSE FLEA, *PLEOCHAETOIDES BULLISI,* N. GEN. N. SP., FROM TEXAS[1]

GUSTAF F. AUGUSTSON[2]

Incident to field studies on Bullis Fever,[3] some fleas were obtained from white-footed mice (*Peromyscus*) that are here illustrated and described as new to science.

Family DOLICHOPSYLLIDAE

Pleochaetoides new genus

Chaetotaxy of head like that of *Pleochaetis:* eyes moderately pigmented, small; labial palpus five (5) segmented; in males, tergal plate VIII large, upper and lower posterior angles of clasper small and about equal, sternite VIII reduced, with two large membranous flaps; chaetotaxy of tarsi, legs, and thoracic segments as in *Pleochaetis.*

Genotype: *Pleochaetoides bullisi* Augustson.

This new genus, as indicated, is closely allied to *Pleochaetis* Jordan (1933). Due to the present status and description of *Pleochaetis,* as given by Ewing and Fox (1943), a new genus was felt necessary to hold the fleas here reported on. Ewing and Fox (1.c.) reduced *Pleochaetis* to subgeneric rank under *Trichopsylla* Kolenati (1863). This latter was revived on the strength of Baker's (1904) type designation. In Kolenati's original description (1.c.) no mention was made of a pronotal ctenidium. Jordan (1.c.) recognized this when he erected *Pleochaetis,* stating, "the genus (*Trichopsylla*) was described as having no ctenidium on head and thorax." All species dealt with by Ewing and Fox (1.c.) under *Trichopsylla* possess at least a pronotal ctenidium. Baker's monographic work (1.c.), according to International Rules, may necessitate the continued use of *Trichopsylla,* as so designated, but the employment of established genera, as outlined by Ewing and Fox (1.c.), as subgenera within it appears illogical at present. If, and when, *Pleochaetis* is recognized as a genus by siphonapterists, the genus *Pleochaetoides* may perhaps be relegated to subgeneric status.

Pleochaetoides bullisi n. sp.

Holotype Male

Head (Fig. 1): Frontal tubercle small, accuminate; preantennal region with three (3) rows of bristles, eight (8) in upper row, three (3) in each lower row; eye small, not darkly pigmented; genal process sharply rounded; bristles on second segment of antenna reduced; postantennal region with three (3) rows of bristles (including submarginal row of occiput), three (3) in anterior row, five (5) in each posterior row; labial palpus slightly shorter than fore coxa; maxillae sharply accuminate.

Thoracic and Abdominal Segments (Figs. 2, 3 and 4): Pronotal ctenidium of sixteen (16) slender spines; tergal teeth present, small, two (2) on metathorax, two (2) on abdominal tergites

Received for publication, September 23, 1944.

[1] Contribution from the Eighth Service Command Laboratory, Fort Sam Houston, Texas.

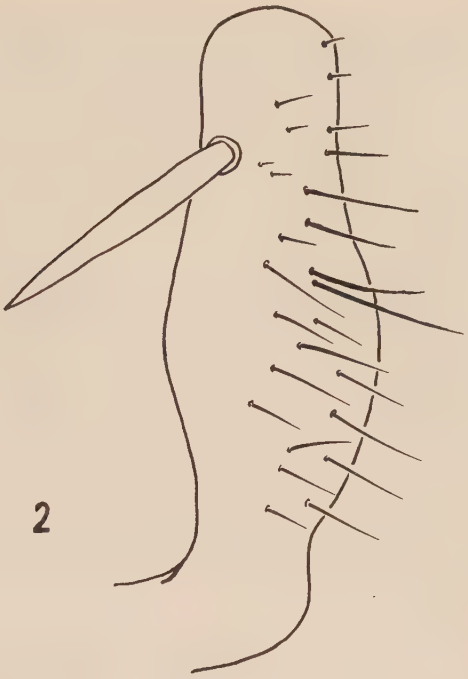
[2] 1st Lieutenant, Sanitary Corps, Army United States, Entomologist.

[3] Livesay, H. R., and Pollard, M. Laboratory report on a clinical syndrome referred to as Bullis Fever. Am. Jour. Trop. Med. **23**: 475–479. 1943.

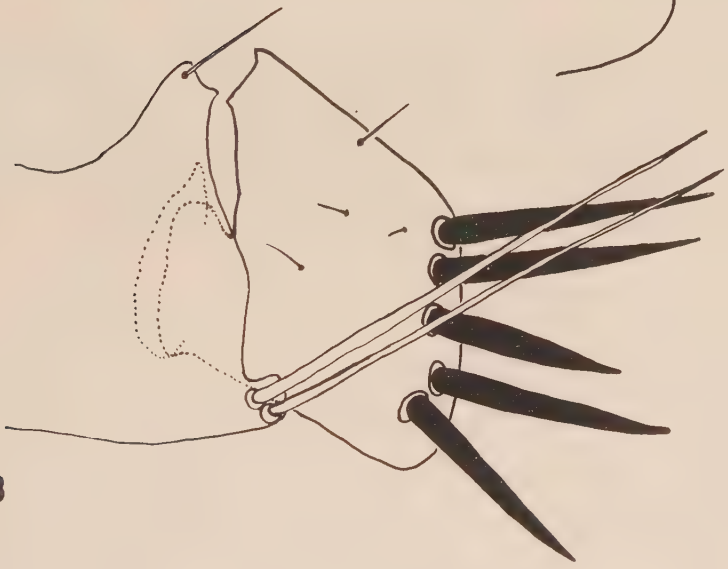
PLATE I

FIG. 1. *Pleochaetoides bullisi* Aug., head, holotype male.
FIG. 2. *Pleochaetoides bullisi* Aug., sternite IX, holotype male.
FIG. 3. *Pleochaetoides bullisi* Aug., finger, clasper, holotype male.
FIG. 4. *Pleochaetoides bullisi* Aug., sternite VIII, holotype male.

1



2



3

4

I to IV; a single, large antepygidial bristle; tergite VIII very large, the postero-ventral margin of which joins sternite VIII; sternite X (XI of authors) reduced to small flaps; finger (Fig. 3) with rounded postero-ventral angle, tapered, narrow antero-dorsal angle, five (5) long, pointed spiniforms, the middle member slightly shorter than others; clasper (Fig. 3) with two (2) long acetabular bristles, which are situated postero-ventral to acetabulum on a narrow extension of the ventral margin of the clasper, process of clasper narrow; sternite IX (Fig. 2) broad, not divided into lobes, a single prominent, modified bristle in the upper anterior half, with numerous small setae in the lower posterior half; sternite VIII (Fig. 4) apparently reduced to a small basal sclerite, with two (2) large membranous flaps; penis long and slender, spring with one full turn.

Legs: Tarsus V with five (5) lateral plantar bristles, the first pair distinctly displaced medially; length of hind tarsus I not exceeding II and III together; coxa II with long, thin bristles in apical half only; outer surface of fore femur with seven (7) small setae.

Holotype: A male, collected by the writer and Dr. J. M. Brennan at Camp Bullis, Bexar County, Texas, 1 June 1944, from *Peromyscus pectoralis laceianus.* Deposited in the U. S. National Museum, Washington, D. C.

Paratype: A male, collected as above, retained in the Eighth Service Command Laboratory, Fort Sam Houston, Texas.

Type Host: Peromyscus pectoralis laceianus.

Type locality: Camp Bullis, Bexar County, Texas.

Remarks: This new flea is named after the locality from which it was recovered. Host determination is that of Dr. L. Dice, Department Vertebrate Zoology, University of Michigan.

References

Baker, C. F. 1904 A revision of American siphonaptera, or fleas, together with complete list and bibliography of the Group. U. S. Nat. Mus. Proc. **27**: 365–469.

Ewing, H. E. and Fox, I. 1943 The fleas of North America. U. S. Dept. of Agric. Misc. Pub. **500**: 1–143.

Jordan, K. 1933 A survey of the classification of the American species of *Ceratophyllus* s. lat. Nov. Zool. **39**: 70–79.

Kolenati, F. A. 1863 Soc. Ent. Rossicae Horae **2**: 32.

PHYSIOLOGICAL RESPONSES OF *NEOECHINORHYNCHUS EMYDIS* (ACANTHOCEPHALA) TO VARIOUS SOLUTIONS

HARLEY J. VAN CLEAVE AND ELIZABETH L. ROSS
University of Illinois, Urbana

Various writers have called attention to the fact that the body of a normal, living acanthocephalan is distinctly flattened and somewhat wrinkled (Hamann, 1891; Looss, 1901; Van Cleave, 1941; et al). Attainment of a turgid, cylindrical form in these worms is attributable to the operation of two unrelated sets of factors, one of which results in a normal phenomenon of plumping and the other is explainable as a physiological response to unfavorable change in the environment. The development of eggs in the fertilized female produces a normal, functional alteration of body shape, causing the body of the gravid female to assume a distended, turgidly cylindrical form. Practically all preserved adult and post-larval individuals of both sexes and in all stages of growth have this same cylindrical form, attributable not to normal, functional adjustment but to physiological changes which take place as a response to abnormal or unnatural media.

The importance of the body covering in the life processes of the individual is particularly significant in this group of parasitic worms. In the complete absence of all organs for digestion, the acanthocephalan depends entirely upon the permeability of its body wall for admission of all metabolic materials and, with exception of a few species which have specialized excretory organs, the body wastes must likewise pass outward through the body covering.

One of the most distinctive features of the subcuticula, which comprises by far the greatest bulk of the body wall, is a series of intercommunicating spaces and canals. At least some of these are united into continuous vessels.

While extensive experimentation has been conducted on maintenance of cestodes, trematodes, and nematodes *in vitro,* only one paper dealing specifically with ACANTHOCEPHALA has come to the writers' attention. This is the brief study by Gettier (1942). In that paper no mention of the response of the worms to the various media is given, except as length of survival in each medium is recorded.

The maintenance of a collapsed body by ACANTHOCEPHALA within their normal habitat, followed by distortion on removal to water or histological fixatives, suggests the desirability of determining the effects of various media on state of the body. This problem immediately finds direct application in the study of media used for maintaining ACANTHOCEPHALA for experimental purposes outside the body of the host. In testing media, the length of time that a worm will survive should at the same time be supplemented by observations on the normal or abnormal conditions induced by the medium.

Beginning in 1942, the junior author of this paper performed a series of tests to determine the effects of various media on *Neoechinorhynchus emydis* (Leidy, 1851). This species was selected because of its availability throughout the year and because its relatively small size ensures convenience in handling. Since the adult worms live for many months in the turtle intestine, even when the host is not feeding, a continuous supply was assured.

Received for publication, August 29, 1944.

In the present study attention was directed primarily to maintenance of normal body conditions and to the environmental factors which cause alteration of body form. Earliest observations on body form had given ample evidence that many media produce turgidity of worms *in vitro*. Several series of experiments were devised to determine the effects of various solutions on body form. As a further program, a series of experiments was arranged to determine the possibility of restoring normal body form after worms had become turgid. As a check to these studies *in vitro,* an extended series of experiments was performed to determine the possibility of altering, at least temporarily, the environment in the host intestine so as to induce changes *in vivo* paralleling those produced *in vitro*.

The most pronounced effects upon *N. emydis* were observed when worms from a freshly opened turtle intestine were placed in tap water. From a fairly long series of trials, no individual remained alive for more than 6 hours in tap water and in every instance the body became turgidly cylindrical in less than an hour after being placed in the water. In order to check the otherwise uncontrolled factors regarding the condition of the worms (due to relative age, their physiological states, or the condition of the host) several experiments were performed in which some of the worms from the same host individual were placed in tap water at the same time that others were introduced into various other media, as discussed later in this paper. Invariably, those individuals in the water died in 6 hours or less while those in salt solutions lived a longer period. The length of the survival and shape of the body were correlated with the strength of the solution.

Gettier (1942) found that 0.5% sodium chloride to which small amounts of calcium chloride had been added kept specimens alive on the average of 20.3 days. In the present series of experiments, the solution most used was 0.5% sodium chloride to which 0.02% calcium chloride had been added. Of several hundred worms subjected to this treatment, most individuals retained their flattened, normal condition for from two to four days, after which they became turgid and lived for total periods of from 5 to 20 days outside the body of the host. While the worms continued to live for relatively long periods in this hypotonic solution, they soon lost normal appearance (in from 2 to 4 days) and consequently they were in distinctly abnormal condition for most of the period of their survival.

The rather striking individual differences in length of time that the worms survived in experiments under identical treatment emphasizes the fact that the physiological state of the worms at the outset of the experiment could not be determined.

Change to fresh medium and handling of vials and Petri dishes incident to the frequent observations on the worms seemed to be responsible for reduction in the survival time for many individuals. A series of preliminary experiments gave evidence that these parasites live longest in media from which contact with free atmospheric air is excluded. This was accomplished by completely filling the container with medium and then loosely stoppering with a cork to exclude all air space.

Two experiments with *N. emydis* in frog Ringer's produced worms which were very active for the first day and remained fairly active for from 3 to 6 days. After about the sixth day their bodies became greatly distorted and turgid and they remained in this misshapen, inactive condition for from 4 to 8 days when they died, after a total of from 10 to 14 days in frog Ringer's. Judging from the swelling of the worms, frog Ringer's is hypotonic to *N. emydis*. Although the balanced salt

solution maintains life for fairly long periods, the worms soon become abnormally swollen and distorted.

It is clear from the foregoing that solutions previously recommended for physiological work with turtles and for maintaining ACANTHOCEPHALA outside the body of the turtle host have extremely adverse effects on *Neoechinorhynchus emydis,* causing the body to become inordinately distended and turgidly cylindrical. Since normal saline solutions are so commonly recommended as a medium in which to examine living worm parasites and as a bath for removal of mucus and other foreign material preliminary to fixation, the writers decided to test the effects of higher concentrations of sodium chloride on *N. emydis.*

Specimens transferred directly to 0.85% sodium chloride for washing and then placed in a fresh stock of this same solution, retained their flattened body form, with considerable wrinkling of the surface, for 12 of the 14 days of their survival outside the body of the host. In yet another experiment with 0.85% sodium chloride, the worms remained flat 13 of the 15 days of life in the medium. In 0.8% sodium chloride, specimens became turgid in approximately 10 days and died on the tenth day. These results indicate that *in vitro,* solutions of from 0.8 to 0.85% sodium chloride are essential for maintaining the normally flattened body form of *Neoechinorhynchus emydis.*

In several experiments with 0.75% sodium chloride, the worms survived for from 9 to 13 days although they became distinctly turgid on the second to the fourth day and remained in that condition for the remainder of their lives. When specimens were placed in 0.7% sodium chloride, few of them lived more than 10 days and all became turgid on the third or fourth day, showing that the body wall in this lower concentration could not function normally as a membrane to control the passage of liquids through it.

The readiness with which the body of *N. emydis* responds to hypotonic solutions, changing from its normal, flattened form to turgid, cylindrical form, offers opportunity to examine the possibility of reversing this plumping reaction. With worms once plumped, *in vitro,* is it possible to restore them to their normal form? In one experiment, worms removed from the intestine of a turtle were placed in tap water, where they were allowed to remain for one hour. At the end of this time they were highly turgid. Upon transfer from water to 0.85% sodium chloride, they soon began to lose their turgidity and within five hours had become fully flattened. Apparently they were not seriously affected by the sudden changes in the medium for in this and other experiments some individuals survived for 8 to 9 days. However, in one experiment the alteration back to normal body form was not permanent. Three days after the removal from water to 0.85% sodium chloride the bodies became turgid again, even in the hypertonic solution. Although some of these last-mentioned individuals survived a total of 9 days, normal body permeability was obviously somewhat modified.

The readiness with which living specimens of *N. emydis* alter their body form when subjected to hypotonic solutions *in vitro,* offered a challenge to investigate the possibility of changing the body form while the worms still remained normally attached within the intestine of the living turtle. Solutions identical with those used in the series of *in vitro* experiments were introduced into the intestine of the turtle by means of a tube inserted down the oesophagus of the living host. At varying

intervals following the oral administering of fluids, the turtles were autopsied in order to observe the effects of the media introduced upon the body form of the worms *in situ*.

In an experiment (Dec. 20, 1943), 20 cc of dechlorinated tap water were introduced into the digestive tract of a turtle. Upon autopsy one hour later all of the worms, even the smallest and most immature males, were in a turgid state. Some of the worms removed to tap water in a Petri dish survived for only about 3 hours, others placed in 0.5% sodium chloride and 0.02% calcium chloride lived for periods ranging from a few hours to 2 days.

Oral injection of 20 cc of 0.8% sodium chloride was followed by autopsy after 1.5 hours. None of the worms were turgid and, furthermore, there was no evident bodily distortion in the bodies of worms removed to the same solution for the 10 days of their survival. Similar results followed oral injection of 0.85% sodium chloride. When removed from the intestine to 0.85% sodium chloride in a Petri dish, the bodies remained undistorted for the full 12 days of life outside the host. In one experiment, a single hour elapsed between administering the 0.85% solution and the autopsy, in another, 4½ hours, but there was no observable difference in the response of the worms in the two instances.

To test the possibility of altering and subsequently restoring the body form of worms still within the unopened intestine of the host, parallel to the series of experiments *in vitro*, a turtle was given an oral injection of tap water. Upon autopsy, after two hours, 15 worms were observed, all attached to the intestine wall but all turgidly cylindrical in form. As these worms were removed from the host they were separated into four different groups each of which received different treatment. The turgid worms which were removed to 0.70 and 0.75% sodium chloride remained turgid while those placed in 0.80 or 0.85% sodium chloride regained their normal body form. It is thus clear that the response of worms subjected to the influence of water in the turtle intestine followed by removal to salt solution, is in all essential respects parallel to the response observed when the experiments were conducted wholly *in vitro*.

The normally flattened bodies of males and non-gravid females of *Neoechinorhynchus emydis* are readily altered by changes in the surrounding medium. Hypotonic solutions cause the body to become inordinately swollen and turgidly cylindrical. Even changes in the content of the host intestine may induce changes in body form of the living worms attached within the intestine. Radical changes in body form induced by water or hypotonic solutions, either *in vitro* or *in vivo*, cause the death of the parasites.

References Cited

Gettier, D. A. 1942 Studies on the saline requirements of *Neoechinorhynchus emydis*. Proc. Helm. Soc. Washington **9**: 75–78.

Hamann, O. 1891 Die Nemathelminthen. Beiträge zur Kenntnis ihrer Entwicklung, ihres Baues und ihrer Lebensgeschichte. Jena.

Looss, A. 1901 Zur Sammel- und Conservierungs-technik von Helminthen. Zool. Anz. **24**: 302–318.

Van Cleave, H. J. 1941 Relationships of the Acanthocephala. Am. Nat. **75**: 31–47.

STUDIES OF SHEEP PARASITES. IV. SURVIVAL OF SHEEP NEMATODES ON PASTURE DURING THE FALL MONTHS*

PHILIP A. HAWKINS, C. L. COLE AND E. E. KLINE

The length of life of the infective larvae of the strongylids is of both practical and theoretical importance. To the animal husbandryman it determines how long pastures must be vacated until live stock may be safely returned, to the helminthologist it explains the activity of these larvae under natural conditions. Studies of this type have been sadly neglected until recent years.

Ransom (1906) found that the larvae of *Haemonchus contortus* showed little reduction in the number of food granules when kept out of doors from December 27 to March 22. Ransom (1908) also reported that infested pastures will not become free of stomach worm infection between October 25 and June 16 at Washington, D. C. However, this writer later (1910) reported that if a pasture was free of sheep for a year it would practically free itself of stomach worm larvae. Although Veglia (1915) showed that the infective stomach worm larvae were short lived the conclusions of Ransom have been generally accepted. These conclusions as to the longevity of stomach worms *H. contortus* have in general been confirmed by Dikmans and Andrews (1933), Kammlade, Graham and Boley (1936) in Illinois, Boughton and Hardy (1937) in Texas and Baker (1939) in New York. It is probable that the test lambs of Ransom (1906) and Kammlade, Graham and Boley (1936) were infected before being placed on pasture. However, Veglia (1915) and Mönnig (1930) showed that most of the trichostrongylid larvae were not capable of surviving more than 2–3 months in the dry weather of South Africa. Griffiths (1937) and Swales (1939 and 1940) showed in Southern Canada that pastures infested with *Haemonchus contortus* and *Oesophagostomum columbianum* were freed of infestation over the winter months, although other trichostrongylid larvae were able to survive in small numbers. Shorb (1943) at Beltsville, Maryland, found there was no survival on grass plots of *Haemonchus contortus* from December to April. Shorb (1944) noted in a study of infested grass plots that a few infective larvae were capable of surviving from August or October to the following April or May but these were sluggish, vacuolated and probably non-infective. Dinaburg (1944) also reports on the short life of *H. contortus* larvae and their failure to live over the winter. Sarles (1943) also showed there was no carryover on pasture in Maryland. Sarles (1943) demonstrated the overwinter loss of nodular worm larvae from a sheep pasture at Beltsville, Maryland. Rebrassier (1933) in Ohio reports in an abstract that nodular worm larvae are capable of surviving at least one winter on pasture. Shorb (1942) reported that on summer pastures in Maryland all the strongylid parasites of sheep were destroyed in $2\frac{1}{2}$ months, and that even an abundance of shade probably does not protect materially these preparasitic stages. Shorb also showed that there was no development to infectivity during the late fall and winter, but that small numbers of *Ostertagia, Trichostrongylus* and probably *Nematodirus* survive the winter and are infective in the spring. Griffiths (1937)

Received for publication, October 11, 1944.

*Journal Article No. 726 (n.s.) of the Michigan Agricultural Experiment Station, East Lansing, Michigan.

also showed that *Ostertagia, Trichostrongylus* and *Nematodirus* would survive the winter in southern Canada. Kates (1943) reported that there was no evidence of survival of *Oesophagostomum* or *Bunostomum* on pasture over the winter, but that *Trichostrongylus* and *Haemonchus* were capable of survival in small numbers and *Nematodirus* and *Ostertagia* in moderate numbers. Therefore, it is apparent at the present time that there has been a reversal of Ransom's earlier conclusions on the survival of *H. contortus*. It is probable that *Haemonchus contortus, Oesophagostomum columbianum* and *Bunostomum trigonocephalum* are not capable of survivng the winter months under most conditions and that *Ostertagia, Trichostrongylus* and *Nematodirus* may survive in small numbers. During the dry summer months it is probable that all the infective larvae are killed in 2 or 3 months.

METHODS

The lambs used in this experiment were removed from the ewes at birth and bottle-fed cows' milk. They were kept in screened box stalls, bedded with straw, and the pens cleaned twice each week. The lambs had free access to alfalfa hay, oats, water and salt. Repeated fecal examinations did not reveal the presence of any parasitic infection except coccidia and *Strongyloides*.

The experimental pasture was alfalfa-brome grass and about $\frac{1}{4}$ acre in size. There was no shade on this plot. A group of untreated ewes and their lambs had access to this land from May 22 to September 1. This group was infected with *H. contortus, Ostertagia, Trichostrongylus, Cooperia, Nematodirus, Oesophagostomum, Chabertia, Trichuris ovis* and *Moniezia expansa*. Parasite-free lambs were placed on this pasture for two weeks, removed to a screened straw bedded box stall for three weeks, killed, the nematodes removed, counted and identified.

RESULTS AND DISCUSSION

Weather data for the period tested are presented in Table 1. The number of nodules found on the gastro-intestinal tract and the number and species of worms

TABLE 1

	Temperature			Precipitation		Solar and sky radiation, gram calories/cm²
	Mean	Maximum	Minimum	Total inches	Snowfall, inches	
September	57.5	86	33	3.45	0.0	8,833.7
October	48.4	77	32	1.80	1.7	6,173.5
November	35.1	64	19	2.16	3.1	3,137.1
December	25.4	48	−3	0.45	1.9	3,455.9
January	28.2	63	3	1.32	2.3	3,225.7

Courtesy of the U. S. Soil Conservation Service Weather Station, 100 yards from pasture.

TABLE 2

	September 12	October 3	November 4	December 23	January 15
Nodules	15	51	4	0	0
H. contortus	43	26	0	0	0
Ostertagia	392	181	4	42	102
Cooperai	592	320	279	80	}
Trichostrongylus	112	35	46	22	} 1000
Nematodirus	696	1148	1325	682	}
O. columbianum	0	1	1	0	0
Chabertia ovina	1	8	1	0	0
Trichuris ovis	2	74	3	63	8
Moniezia expansa	7	0	2	1	0

recovered are presented in Table 2. Unfortunately the specimens found in the small intestine for January 15 were accidentally discarded so that only the total number of worms is presented. However, it is known from fecal examinations that *Trichostrongylus* and *Nematodirus* were present, whether *Cooperia* had disappeared cannot be stated although the eggs were absent.

H. contortus larvae were killed on the pasture in two months or less as shown by the fact that by November 4 infection of lambs failed to take place, and no infection with this species was noted during December or January. *O. columbianum* was greatly reduced in number after 2 months and had disappeared in 3½ months. *Chabertia ovina* larvae also had been destroyed on the pasture in 3½ months. However, in 4½ months the infective larvae of *Ostertagia circumcincta, Trichostrongylus colubriformis, Nematodirus* and *Trichuris ovis* were still alive and capable of infection. Whether the larvae of *Cooperia curticei* were still alive after 4½ months unfortunately could not be determined, although they were still present at 3½ months.

In this area the common stomach worm and nodular worm are of greatest economic importance, therefore it was gratifying to note that they disappeared so rapidly from the pasture. Permanent pastures in the generally accepted sense of the term cannot be blamed for perpetuating these parasites from one year to the next. Hawkins et al (1944) have shown that a small residual infection is carried over the winter months in the ewe. This infection is multiplied by the ewe in the first warm weather of spring, and the lambs finally become infected in the early summer. It is interesting to note that there is a marked age resistance in the lambs preventing their early acquisition of infection.

Therefore, it appears that under the climatic conditions of Michigan the most important parasites economically, *H. contortus* and *O. columbianum,* are not perpetuated by the pastures, but by the breeding flock.

SUMMARY

1. Pastures infested with *Haemonchus contortus* are apparently freed of infestations in 2 months in the late summer and early fall, with *Oesophagostomum columbianum* and *Chabertia ovina* in 3½ months.

2. *Ostertagia circumcincta, Trichostrongylus colubriformis, Nematodirus* and *Trichuris ovis* larvae were still viable after 4½ months on pasture.

3. The breeding flock appears to be of greatest importance in perpetuating parasites.

REFERENCES

BAKER, D. W. 1939 Survival of worm parasite infection on New York State Pastures. Cornell Vet. **29**: 45–48.

BOUGHTON, I. B. AND HARDY, W. T. 1935 Texas Agr. Exp. Sta. 48th Ann. Rep.; 1936 49th Ann. Rep.; 1937 50th Ann. Rep.; 1938 51st Ann. Rep.

DIKMANS, G. AND ANDREWS, J. S. 1933 A note on the time of survival of larvae of *Haemonchus contortus, Ostertagia circumcincta,* and *Nematodirus spathiger,* on pastures. J. Parasitol. **20**: 107.

DINABURG, A. G. 1944 The survival of the infective larvae of the common ruminant stomach worm, *Haemonchus contortus,* on outdoor grass plots. Am. J. Vet. Res. **5**: 32–37.

GRIFFITHS, H. J. 1937 Some observations on the overwintering of certain helminth parasites of sheep in Canada. Canad. J. Res. Sec. D. **15**: 156–162.

HAWKINS, P. A., COLE, C. L., KLINE, E. E. AND DRUDGE, J. H. 1944 Studies of sheep parasites. I. The course of untreated nematode infections. Vet. Med. **39**: 154–161.

KAMMLADE, W. G., GRAHAM, R. AND BOLEY, L. E. 1936 The persistence of stomach worms on blue grass pasture. Am. Soc. Anim. Prod., Rec. Proc. Twenty-ninth Ann. Meeting 169–172.

KATES, K. C. 1943 Overwinter survival on pasture of preparasitic stages of some nematodes parasitic in sheep. Proc. Helm. Soc. Washington **10**: 23–25.

MÖNNIG, H. O. 1930 Studies on the bionomics of the free-living stages of *Trichostrongylus spp.* and other parasitic nematodes. Union South Africa, Dept. Agr. Rpt. Dir. Vet. Serv. and Anim. Indus. **16**: 175–198.

RANSOM, B. H. 1906 The life history of the twisted wireworm (*Haemonchus contortus*) of sheep and other nematodes (Preliminary report) U. S. Bur. Anim. Indus. Cir. 93.

————1908 The prevention of parasitic infection in lambs. Report of first series of field experiments. U. S. Bur. Anim. Indus. Ann. Rpt. (1906) **23**: 207–212.

————1910 The prevention of losses among sheep from stomach worms (*Haemonchus contortus*) U. S. Bur. Anim. Indus. Cir. 157.

REBRASSIER, R. E. 1933 Longevity of *Oesophagostomum columbianum* larvae. 51st Ann. Rep. Ohio Agr. Exp. Sta. (Bull. 516) (1931–2) : 81.

SARLES, M. P. 1943 Overwinter loss of nodular worm larvae from a sheep pasture and its bearing on the control of nodular worm disease. J. Parasitol. **29**: 263–269.

SHORB, D. A. 1942 Survival of sheep nematodes in pastures. Jr. Agr. Res. **65**: 329–337.

————1943 Survival on grass plots of eggs and preinfective larvae of the common sheep stomach worm, *Haemonchus contortus*. J. Parasitol. **29**: 284–289.

————1944 Survival on grass plots of eggs and larvae of the stomach worm, *Haemonchus contortus*. J. Agr. Res. **68**: 317–324.

SWALES, W. E. 1939 Factors influencing the number and pathological effects of nematodes in the alimentary tract of sheep in Canada. 3rd Internat. Cong. Microbiol.

————1940 The helminth parasites and parasitic diseases of sheep in Canada. II. Notes on the effect of winter upon the free living stages of nematode parasites of sheep on pastures of eastern Canada. Canad. J. Comp. Med. **4**: 155–161.

VEGLIA, F. 1915 The anatomy and life history of the *Haemonchus contortus*. (Rud.) Union South Africa Dept. Agr. Rpt. Dir. Vet. Serv. and Anim. Indus. **3–4**: 347–500.

DEVELOPMENT OF A POWDER TREATMENT FOR THE CONTROL OF LICE ATTACKING MAN

By R. C. Bushland,[1] L. C. McAlister, Jr., G. W. Eddy, Howard A. Jones, and E. F. Knipling

U. S. Department of Agriculture, Agricultural Research Administration, Bureau of Entomology and Plant Quarantine[2]

Military personnel are especially subject to infestation by one or more species of lice. The body louse, or "cootie," *Pediculus humanus corporis* Deg., has been incriminated as a vector of several important diseases, such as typhus fever, trench fever, and epidemic relapsing fever. The head louse, *P. humanus humanus* L., is also considered capable of transmitting these diseases. The crab louse, *Phthirus pubis* (L.), is not known to carry any disease, but the irritation produced by an infestation can become serious in some individuals.

Because of the tremendous importance of typhus in military operations,[3] research was undertaken to develop a powder for the control of body lice. Such a powder should be nontoxic to man when in contact with the body for long periods. Not only should the powder kill lice present at the time of treatment, but the treated clothing should remain effective in killing lice for several days. This residual effect was particularly necessary so that in the delousing of a unit, which might require several days, treated men would not become reinfested by contact with infested individuals. If the treatment did not remain effective beyond the incubation period of louse eggs, it was desirable that an ovicide be incorporated to destroy as many eggs as possible.

This report outlines the general procedures used in the louse investigations and summarizes the tests which led to the recommendation of the MYL powder for use by the armed forces. The work was begun in the spring of 1942 at the Orlando, Fla., laboratory of the Bureau of Entomology and Plant Quarantine. Another powder has since been developed (Bushland et al 1944), which will be discussed in a subsequent article.

TEST METHODS

The body lice used in the insecticidal tests were taken from an incubator colony[4] reared in a manner modified from that described by Moore and

Received for publication, September 23, 1944.

[1] Now Captain, Sanitary Corps, Army of the United States.

[2] The work described in this paper was done under a transfer of funds, recommended by the Committee on Medical Research, from the Office of Scientific Research and Development to the Bureau of Entomology and Plant Quarantine. The authors are indebted to W. E. Dove, chief of the Division of Insects Affecting Man and Animals, who was located in Orlando during the early stages of the work.

[3] Appreciation is expressed to Colonel W. S. Stone, of the Office of the Surgeon General of the Army, who strongly urged that research be undertaken to develop an insecticide, preferably a powder, that could be used readily by the individual soldier to control body lice, and whose active interest in this project greatly encouraged the authors.

[4] The parent stock consisted of a mixed collection made in Washington, D. C., by W. E. Dove and W. G. Bruce, and in Orlando by the senior author. During the period of this work the colony was maintained by G. H. Culpepper and N. B. Carson.

Hirschfelder (1919). The colony was held at a temperature of 30° ± 2° C in fairly humid incubators (approximately 85 per cent), and the lice were removed twice daily for feeding on human hosts. The maintenance of this colony has recently been described (Culpepper 1944). Recently fed young adult lice were used in all laboratory tests.

Beaker tests.—Since hundreds of organic compounds were to be evaluated as toxicants for body lice, it was necessary to devise a rapid means of eliminating ineffective materials. In the first elimination procedure test materials

FIG. 1. Introduction of lice into sleeve in arm-and-leg test.

were dissolved at a concentration of 1.0 per cent in a suitable solvent, usually acetone but in some cases benzene, chloroform, or other solvent. Pieces of woolen cloth about 1 inch square were immersed in the test solution and then dried at room temperature for 2 hours to remove the solvent. The impregnated pads were then placed in 50-ml beakers and 10 lice introduced. The test beakers were held under the same conditions as was the louse colony. Since the instinct of lice is to cling to cloth, if the chemical with which the cloth was impregnated was sufficiently toxic, the lice were killed. Mortality records were taken after 24 hours. If a material was toxic, lice were added at

intervals to determine the duration of effectiveness of the treatment. Untreated controls were present in all tests, and it was found that, in the absence of an insecticide, lice survived the test conditions for 24 hours with negligible mortality.

Arm-and-leg tests.—Compounds found to be toxic in the beaker test were next tested as powders. The substances were deposited on pyrophyllite from an acetone solution to obtain powders containing 5.0 per cent of test material. These powders were evaluated by a method designated as the "arm-and-leg test."

In this test powders were spread uniformly over the inner surface of balbriggan cloth sleeves and legs at a dosage of 3.0 grams per garment, and rubbed into the fabric with the fingers. The garments had an area of about 65 square inches, and the dosage used was equivalent to about 2 ounces of powder per suit of winter under-

FIG. 2. Arm-and-leg treatments on subjects.

FIG. 3. Examination of lice after exposure in treated sleeve.

wear. A given material was applied to at least two, and usually four, treated sleeves or legs. The treated garments were placed on the arms and legs of research subjects and the lower openings fastened to the skin with adhesive tap. Twenty-five body lice on a small cloth pad were placed in each garment, and the top was sealed with tape. Figs. 1, 2, and 3 illustrate the method.

During the interval between introduction of lice and subsequent examination, the subjects were allowed to continue their normal activities. Examinations were made after the garments had been worn 24 hours. If the treatment was effective the garment was reinfested. Reinfestation and examination were repeated at daily intervals for 3 days and thereafter every 2 days until the treatment failed to kill all the lice. In some cases, for comparative purposes, tests were continued until a large percentage of the lice recovered were found to be normal.

At intervals untreated garments were used as controls, and frequently all the 25 lice were found at the time of examination. On an average, however, about 20 normal lice were recovered after 24 hours' confinement under untreated garments. Some of the insects were accidentally crushed in the host's

normal activities. Rarely did any escape, and the research subjects underwent the tests without fear of becoming infested.

The results obtained by the arm-and-leg method are not considered to represent those that would be attained under natural conditions. In these tests the garments were more heavily treated than in recommended practice and, since the lice were confined, they could not migrate to untreated areas. The treatments gave a greater degree of effectiveness than could have been obtained in practical louse control, but it is believed that materials that failed in these tests could not have succeeded under natural conditions.

By this method treatments could be quite accurately compared, since four materials could be tested simultaneously on one man. By replicating the treatments on several men and rotating the position of the treatments, rather accurate evaluations were made.

In addition to being used for tests of powders, the sleeves and legs were also used in impregnation studies wherein they were first dipped in or sprayed with solutions of insecticides. When dry, the impregnated garments were tested in the usual manner.

Tests of ovicides.—Louse eggs for ovicide tests were obtained from the stock culture. In the routine rearing procedure ovipositing lice were kept on woolen cloths about 1 inch square, and these pads were changed every 2 days. Thus a freshly removed pad contained eggs varying in age from newly laid to 2 days old, and pads with eggs near the point of hatching also contained eggs within 2 days of hatching. In the original tests these two age groups were used, but more recently only eggs 4 to 6 days old have been used for ovicide tests.

The materials were evaluated as powders and as solutions. To test a powder a pad bearing approximately 200 eggs was placed in a small paper bag (one-fourth pound size) with one-half teaspoonful (approximately 1.2 grams) of a pyrophyllite dust containing the desired concentration of ovicide. The sack was shaken vigorously for about a minute and the pad removed. Treated pads were held in a cabinet at a temperature of $30° \pm 2°$ C and a fairly high humidity (usually 85 per cent) for incubation. After hatching was completed in the controls (similarly dusted with plain pyrophyllite), records were taken, examinations being made under the low power of a dissecting microscope. Solutions were tested by immersing the egg pads for 5 to 10 seconds in an alcohol or acetone solution of the test material. Neither of these solvents is ovicidal. The treated pads were held in a well-ventilated room until the solvent evaporated and were then handled according to the technique described above for powder treatments.

An estimate of the ovicidal effect of a treatment being tested by the arm-and-leg method was also obtainable merely by placing a pad bearing louse eggs within the treated garment.

The laboratory technique described served to eliminate chemicals having little or no ovicidal value. Promising materials were tested further on research subjects infested with eggs.

Tests on grossly infested men.—Experiments with materials that had shown promise in laboratory tests were conducted in a dormitory where men were domiciled during the period required to obtain the necessary data. The subjects were artificially infested with large numbers of lice and eggs to simulate conditions of heavy

natural infestation. These tests served to eliminate many of the materials found promising in arm-and-leg tests.

Each man was artificially infested by introducing adult body lice, usually 500, on his clothing, about 6 hours before the treatment was applied. The time between release of the lice and application of the treatment allowed the lice to migrate to all parts of the garments and to become at least partially established. Further to simulate natural infestation, woolen patches containing several hundred eggs in different stages of incubation were clipped to the garments. Just before the treatment was applied, the numbers of lice present on the underwear, outer clothing, and in the bed of each subject were recorded.

Except in special cases, all the tests were conducted with knitted cotton, winter-weight union suits with long sleeves and legs. The outer garments were of the usual type worn in this climate. In the tests of powders the dosage was 30 grams per suit of underwear. Powders were applied by carefully sprinkling from a shaker-top can over the entire garment and then lightly rubbing into the fabric. Only the inside of the underwear was treated. The outer clothing and the socks worn by the subjects, and their beds, were not treated. In actual practice under field conditions, however, it would be necessary to treat at least the seams of the outer clothing, the socks, and the beds of persons exposed to severe infestations of the body louse.

The degree of control obtained with each material tested was based on daily observations following the treatment. The underwear, the outer clothing, and the bed of each subject were thoroughly searched each day for lice, and the eggs on the clothing were examined for hatching. The number of surviving lice, including the nymphs hatching from the eggs, was recorded.

Further to simulate conditions of natural infestation in treatments that had eliminated all the original infestation of lice, the subjects were reinfested, usually with 100 lice, at the end of the second day following treatment. If the treatment was effective against the reinfestation, the subject was required to wear his underwear continuously for 7 days, at which time he was further reinfested with 100 adults and 100 newly hatched nymphs. If the treatment was effective against the reinfestation introduced at the beginning of the second week, the subject was infested at weekly intervals thereafter until the treatment showed evidence of being ineffective. The garments were not washed during these tests.

Impregnated underwear has been tested by the same method. In testing such garments lice were released in the outer garments of the subject, and 6 hours later the impregnated clothing was put on. Observations were made as in the tests with powders.

DEVELOPMENT OF A LOUSE-POWDER FORMULA

Tests of lousicides.—In the search for a synthetic toxicant for body lice, several hundred compounds were tested by the beaker method, but only about one-fourth of them were found to be lethal. Since most of the materials tested were known to be toxic to one or more species of insects or were related to effective insecticides, it appears that the body louse is highly resistant to insecticides. Of the materials found to be toxic to lice by the beaker test method, only about one-third were lethal as 5.0 per cent powders when tested by the arm-and-leg method. Most of these treatments were completely effective only as fresh applications, and some lice survived when introduced after the treated garments had been worn for a day or longer.

A louse powder containing a synthetic insecticide has recently been recommended (Bushland et al 1944). During the first few months of the work, however, the results with synthetic organic compounds indicated that they could not be expected to furnish an early solution to the problem. Emphasis was then placed on tests of derris and pyrethrum lousicides.

Spencer (1941) found derris powder an effective control for body lice in Canadian troops, and Busvine (1942) also reported success with a powder containing derris. Pyrethrum powder was recommended for use against lice by Simon (1916), was said to be ineffective as a louse treatment by Nuttall (1918), but a fresh powder was claimed to be effective by Symes et al (1942). Little work has been done on the use of extracts of pyrethrum against lice since that of Juillet and Diacono (1925).

Preliminary tests with finely ground pyrethrum flowers (1.25 per cent of pyrethrins) and derris powder (4.8 per cent of rotenone) indicated that neither material was very effective. In six arm-and-leg tests with ground pyrethrum flowers 9 per cent of the insects survived 24 hours' confinement in freshly treated garments, while in eight tests with derris powder an average of 14.5 per cent of the lice survived.

TABLE 1.—*Comparison of effectiveness against body lice of powders containing 1.0 per cent of pyrethrins and 1.0 per cent of rotenone (prepared from extracts) in tests on grossly infested men*

Material	Number of cases	Per cent of lice surviving on indicated days after infestation				
		1 day	2 days	3 days	4 days	5 days
Pyrethrins	2	1.6	1.6	0.4	0.4	0.0
Rotenone	3	14.5	7.6	3.3	1.2	1.2

Louse powders prepared by depositing extracts of pyrethrum and derris on an inert diluent were much more effective. For example, pyrophyllite powders containing 1.0 per cent of pyrethrins, deposited from an acetone solution of a 20 per cent concentrate, were completely effective as fresh treatments in tests by the arm-and-leg method. The survival of lice introduced after 24 hours averaged only 0.3 per cent, and these survivors were unable to crawl or feed. After the subjects had worn the treated garments for 4 days, in 19 tests, lice were again introduced. When counts were made after 48 hours, an average of 7.2 per cent of the lice survived.

In 25 tests with 1.0 per cent rotenone powders prepared with derris extract, in which lice were introduced in freshly treated garments, the 24-hour survival averaged 11.5 per cent. Garments were reinfested after 4 days' wearing in 14 cases, and only 7.3 per cent of the lice survived 48 hours after infestation.

These studies indicated that powders containing pyrethrins killed lice more quickly than those made with rotenone (hence the difference in the 24-hour records on fresh treatments), but that, when sufficient time was allowed for rotenone to produce its toxic effects, there was little difference in the results with the two toxicants.

Typical results, on grossly infested men, of powders containing 1.0 per cent of pyrethrins or rotenone prepared by depositing extracts on an inert diluent are shown in Table 1.

These results substantiate those of the arm-and-leg tests. The slow action of rotenone compared with the pyrethrins is particularly evident. Furthermore, rote-

none-containing powders caused severe dermatitis in the scrotal region in about two-thirds of the subjects. It was therefore necessary to discontinue tests of rotenone powders on grossly infested men. No skin irritation has been noted following the use of pyrethrum on the subjects treated at this laboratory.

Because of these two factors—the more rapid kill of powders prepared from pyrethrum extracts and the dermatitis resulting from rotenone powders—the pyrethrum preparations appeared definitely superior to those containing rotenone. As already mentioned, the synthetic organic compounds tested during the early part of the work failed to give extended protection from reinfestation. Since the armed forces were in need of a louse powder for immediate use, pyrethrins appeared most likely to furnish an early solution to the problem of effective treatment.

Tests of synergists for the pyrethrins.—As the supply of pyrethrum flowers was limited, the inclusion of a synergist in the louse-powder formula to increase the insecticidal efficacy of the pyrethrins was practically essential. Over 200 materials, chiefly synthetic organic compounds, were tested by the arm-and-leg method as synergists for pyrethrum in pyrophyllite powders.

Very striking results were obtained with several of the compounds. It became evident that many synergists when used with pyrethrum were unusually effective against body lice. One of these materials, N-isobutylundecylenamide (IN-930), was outstanding in its performance. Alone as a 2.0 per cent powder IN-930 was nontoxic to lice. The combination of 2.0 per cent of IN-930 and 0.01 per cent of pyrethrins gave complete kill in 24 hours, while 2.0 per cent of this synergist and 0.005 per cent of pyrethrins killed almost all the lice within 24 hours. Since the mortality obtained at these concentrations was equivalent to that obtained with 1.0 and 0.5 per cent of pyrethrins alone, the toxicity of pyrethrins to lice was increased approximately 100 times by the addition of 2.0 per cent of IN-930. This observation is of great importance, since this synergist only doubles the toxicity of pyrethrins in fly sprays. Subsequent to the recommendation of the pyrethrum louse powder, several compounds have been found that approach IN-930 in increasing the initial kill of lice by the pyrethrins.

The duration of effectiveness of pyrethrum treatments was not prolonged by synergists to the same extent that the initial toxicity was increased. Very few of the synergists had long-lasting effects. Of these, IN-930 was the best. In tests by the arm-and-leg method powders containing 0.2 per cent of pyrethrins and 2.0 per cent of IN-930 were lethal to lice introduced after the garments had been worn for at least 8 days. Because of these results and since it was readily available, IN-930 was adopted as the synergist for inclusion in the louse-powder formula.

Tests with pyrethrum antioxidants.—Because pyrethrum powders deteriorate on storage, tests were made with powders containing pyrethrum extract and several common antioxidants. When exposed to air in a thin layer for almost 3 months, pyrethrum powders containing certain antioxidants showed no deterioration, whereas a control powder containing no antioxidant failed to kill lice within 44 days. Of the effective antioxidants, Phenol S (essentially isopropyl cresols obtained as a by-product of thymol manufacture) was selected for use in the louse powder. In subsequent storage tests with the recommended formula, containing 0.25 per cent of Phenol S, the powder did not deteriorate appreciably. When spread in a thin layer and exposed freely to the air for 6 months, the stored powder appeared to be fully

as effective as one freshly prepared. When spread in a watch glass and kept for a month in a constant-temperature oven at 60° C (140° F), a temperature actually encountered in North Africa, the powder showed no evidence of deterioration, but after 2 months at this temperature it was less effective than a freshly prepared control.

Tests with ovicides.—The combination of pyrethrum extract, synergist, and antioxidant was not ovicidal. As the protection to be expected from the treatment was of shorter duration than the incubation period of body louse eggs, it seemed desirable to incorporate an ovicide in the formula. One of the most effective ovicides found by Eddy (1944) was 2,4-dinitroanisole, which, at relative humidities above 70 per cent, was lethal to louse eggs when applied at a concentration of 5.0 per cent in a dust. However, this compound was almost ineffective against eggs at humidities much below 70 per cent. The ovicidal effect of dinitroanisole was increased by the addition of IN-930, and 2.0 per cent of each in a powder at favorable humidities was sufficient to kill eggs in all stages of incubation up to within at least 1 day of hatching. In addition to possessing ovicidal properties, 2,4-dinitroanisole was found to be an effective lousicide.

THE MYL FORMULA

As a result of the foregoing studies, the following formula for a louse powder was developed:

	Per cent
Pyrethrins (from a 20% concentrate)	0.2
IN-930	2.0
2,4-dinitroanisole	2.0
Phenol S	0.25
Pyrophyllite to make 100 per cent	

After extensive tests this powder, which is designated as "MYL," was recommended to the armed forces in September 1942. It has been approved as safe for continued use on human skin.[5]

In laboratory preparation the active ingredients were dissolved in acetone and added to the pyrophyllite. The solvent was then allowed to evaporate and the powder ground with a spatula on a glass plate. Commercial lots were prepared by dissolving the toxicant, synergist, and antioxidant in alcohol denatured with acetone and spraying this solution into the powder. The ovicide in a finely ground state was mechanically mixed with this powder. Frequent biological tests of random samples of commercial preparations purchased by the Army and Navy indicated that this method was generally satisfactory.

In the period since the MYL formula was developed, it has been tested repeatedly by the arm-and-leg method and on grossly infested subjects. At least a week's protection has been obtained under all the test conditions. During warm weather the MYL treatment in arm-and-leg tests usually gave complete protection for 8 days. In cool weather the treatment frequently was effective for 10 or 12 days. In tests with whole suits of underwear on grossly infested men the powder usually killed all lice introduced at the beginning of the second week's wearing, but failed to give complete control of lice introduced after this.

[5] Pharmacological tests of this and other formulas were made by H. O. Calvery, of the U. S. Food and Drug Administration, under a transfer of funds from the Office of Scientific Research and Development.

The MYL powder has been compared with a number of other louse powders and some of the results given below are typical. In table 2 are shown results obtained with MYL, with and without 2,4-dinitroanisole, and with AL-63[6] and 10 per cent lauryl thiocyanate. The last two have been in use in the British Army.

TABLE 2.—*Comparison of effectiveness against body lice of MYL and other powders in tests by the arm-and-leg method*

Treatment	Percentage survival after 48 hours when lice were introduced after treated garments had been worn		
	4 days	6 days	8 days
MYL	0	0.0	0
MYL without 2,4-dinitroanisole	0	0.0	4
AL-63	8	—	—
10% lauryl thiocyanate*	4	9.3	—*

* Not tested simultaneously with the other treatments.

Although the AL-63 was effective as a fresh treatment, it had begun to fail by the fourth day and was discontinued to avoid annoyance to the test subjects. The 10 per cent lauryl thiocyanate was also effective as a fresh treatment, but allowed an appreciable number of lice to survive after 3 days' wearing.

Table 3 gives the comparative results obtained with MYL, with and without 2,4-dinitroanisole, and AL-63 in tests on grossly infested men.

TABLE 3.—*Comparison of effectiveness against body lice of MYL and other powders in tests on grossly infested men*

Treatment	Number of subjects	Number of lice present when treated*	Number of lice surviving on indicated days after infestation—									
			1 day		2 days		3 days		4 days		5 days	
			A.†	N.	A.	N.	A.	N.	A.	N.	A.	N.
MYL	4	1,539	0	0	0‡	0	3	0	0	0	0	0
MYL without 2,4-dinitroanisole	5	1,837	4	0	0‡	0	14	24	0	15	1	37
AL-63	5	758	15	0	5	0	1	2	0	43	0	50

* Several thousand eggs were also introduced with the initial infestation of adult lice.
† A = adults ; N = nymphs.
‡ At this time 400 to 500 adult lice were added.

It is interesting to note that a number of newly hatched nymphs survived 3 days' wearing of the garment treated with MYL without the ovicide, whereas with the complete MYL formula no nymphs had appeared after 5 days. The AL-63 powder also showed increasing numbers of nymphs. This powder caused dermatitis in the scrotal region of three out of the five subjects.

Speed of knockdown, ability to feed, and kill of lice exposed to MYL.—The time required for a treatment to kill lice or to prevent further feeding is considered highly important from the standpoint of typhus control. Tests were conducted to determine the speed of action of the MYL formula. Hungry lice exposed to MYL for only 10 minutes were unable to feed, which would in some instances be equivalent to their death. All the lice were knocked down or immobilized in 15 minutes' exposure to this powder. With freshly fed lice, about 50 per cent were killed in 6 hours and 100 per cent mortality occurred after 10 hours' exposure. In comparison with insecticides in general, the action of MYL on lice is considered rapid.

[6] A British product containing derris resins and other materials.

Use against crab lice and head lice.—The MYL powder has been used to treat over 100 natural infestations of crab lice at this laboratory. These cases were obtained through the cooperation of the Army Air Forces School of Applied Tactics at Orlando. The powder has also been used for crab louse control by Army and Navy medical officers at Camp Claiborne, La., Patterson Field, Ohio, and the Naval Air Station, Corpus Christi, Tex.

When all hairy portions of the body were dusted with the powder and the treatment was not removed by washing until the following day, all motile forms of the louse were killed. Such a treatment was not sufficiently ovicidal to insure destruction of all the eggs, although cooperating medical officers reported many cases of eradication with a single treatment. It is recommended that a second treatment be applied after 8 to 10 days to kill the nymphs hatching from any eggs that might survive. In treating infestations of crab lice it is essential that all hairy areas be dusted, since these lice are often present on portions of the body sparsely covered with hair.

MYL was used in the treatment of five cases of head lice. Three of the patients had their hair washed 1, 2, and 4 days after treatment. All the motile forms were destroyed, but a few newly emerged nymphs were found on subsequent examinations. In the two cases in which the hair was not washed for at least 10 days, the individuals remained free of lice.

These results appear to indicate that the formula could be employed successfully for the treatment of head lice. A second application should be made 10 to 14 days after the first.

The active ingredients of the MYL powder have been also applied in a liquid formula and found effective at lower concentrations than when employed in the powder treatment.

Use against other pests.—The MYL powder has been used successfully against ants, fleas, bedbugs, and other troublesome insects encountered by troops and is highly regarded in active theaters of war as a general purpose insecticide. The powder has been the standard issue for individual soldiers, and reports indicate that while other items of equipment may be thrown away the 2-ounce cans of MYL are retained.

SUMMARY

Test methods used in the laboratory evaluation of insecticides for the body louse are described. These include procedures for beaker tests, arm-and-leg tests, ovicide tests, and tests on grossly infested men.

The development of an effective louse powder for use by the armed forces is described. The louse powder, the MYL formula, consists of 0.2 per cent of pyrethrins as a toxicant, 2.0 per cent of IN-930 as a synergist, 0.25 per cent of Phenol S as an antioxidant, and 2.0 per cent of 2,4-dinitroanisole as an ovicide, with pyrophyllite as an inert diluent. It was established that this powder does not readily deteriorate even under unfavorable storage conditions.

Laboratory comparisons by the arm-and-leg method and tests on grossly infested men showed the MYL formula to be a superior louse powder. This powder, uniformly applied over the entire inner surface of winter underwear worn by heavily infested men at a dosage of 30 grams per suit, killed all body lice present at the time of treatment. It also killed all eggs with which it came in contact, and gave complete protection against introduced lice for at least a week.

The MYL powder was also found to be an effective control for head lice and crab lice. It is also being employed successfully by troops in war theaters against other important insects, such as fleas, bedbugs, and ants.

Literature Cited

Bushland, R. C., McAlister, Jr., L. C., Eddy, G. W. and Jones, H. A. 1944 DDT for the control of human lice. J. Econ. Entom. **37**(1) : 126–127.

Busvine, J. R. 1942 Head and body lice. Brit. Med. J. **1942**(1) : 334.

Culpepper, G. H. 1944 The rearing and maintenance of a laboratory colony of the body louse. Am. J. Trop. Med. **24** : 327–329.

Eddy, G. W. 1944 A treatment for head lice, crab lice, and scabies. Manuscript approved for publication in War Medicine.

Juillet, A. and Diacono, H. 1925 Emploi des extraits de *Pyrethrum cinerarifolium* Trev. dans le traitement de la pédiculose du corps (*Pediculus corporis,* de Geer). Acad de Méd. [Paris] Bul. **94**(27) : 778–779.

Moore, W., and Hirschfelder, A. D. 1919 An investigation of the louse problem. Minn. Univ., Res. Pub. 8(4), 86 pp.

Nuttall, G. H. F. 1918 Combating lousiness among soldiers and civilians. Parasitology **10**(4) : 411–586.

Simon, A. 1916 Contre les poux. Bul. des Sci. Pharmacol. **23**(9–10, sup.) : 116–117.

Spencer, G. J. 1941 The control of human lice under war conditions. Canad. Entom. **73**(1) : 20.

Symes, C. B., McMahon, J. and Haddow, A. J. 1942 Pyrethrum powder: a preliminary note on its use in chemical control of insect vectors of diseases. East African Med. J. **18**(12) : 360–376.

BOOKS AND MONOGRAPHS RECEIVED

Bercovitz, Z. Taylor, Editor (M.D., Ph.D., F.A.C.P. Assistant Clinical Professor, New York Post-Graduate Medical School, Columbia University. Physician in Charge, Parasitology Service, Department of Health, City of New York. Consultant in Tropical Medicine, Ellis Island Hospital, United States Public Health Service). **Clinical Tropical Medicine.** (By 27 contributors). xvii + 957 pp. 72 chapters, 121 text-figures, 4 color plates, 11 tables, 39 pp. index. Copyright 1944. Paul B. Hoeber, Inc., New York. $14.00.

Bispham, William N. (Colonel, U. S. Army, Retired). **Malaria: Its Diagnosis, Treatment and Prophylaxis.** vii + 197 pp. 17 chapters, 3 color plates, 13 pp. subject index. Copyright 1944. The Williams and Wilkins Co., Baltimore. $3.50.

Cançado J. Romeu (Assistente da II cadeira de Clínica Medica da Faculdade de Medicina da U.M.G.). **Ação Anti-Helmíntica do Látex do "Ficus Glabrata" H. B. K.** (Estudo Experimental e Clínico: Tese apresentada à Faculdade de Medicina da U.M.G. para habilitação a docência livre de Terapêutica Clínica). 186 pp. 17 text-figures, 8 pp. bibliography. Belo Horizonte 1944.

Da Fonseca, José Aluisio B. and Luiz Maragliano Junior. **Manual Pratico de Malária.** 99 pp. 11 chapters, 14 text-figures. Secretaria dos Negocios Da Educação E Saúde Publica, Departamento de Saúde, Serviço de Profilaxia da Malária, São Paulo, 1943.

Gould, Sylvester E. (M.D., D.Sc. Pathologist and Director of Laboratories, Eloise Hospital, Eloise, Michigan. Assistant Professor of Pathology, Wayne University College of Medicine, Detroit). **Trichinosis.** ix + 356 pp. 13 chapters, 128 text-figures, 10 tables, 32 pp. bibliography, 6 pp. author index, 24 pp. subject index. Copyright 1945. Charles C Thomas, Springfield, Ill. $5.00.

Gregg, A. L. (M.A., M.D., M. Ch., B.A.O. (Dublin), D.T.M. & H. (Lond.), L.M. (Rotunda Hospital). Member of Associate Staff of and Lecturer to Nurses of the Hospital for Tropical Diseases, London. Lecturer on Tropical Diseases, Westminster Hospital Medical School). **Tropical Nursing.** 2nd ed. 185 pp. 5 sections, 13 text-figures, 8 pp. index. Copyright 1944. Philosophical Library, Inc., New York.

Gunther, Carl E. M. (M.D., B.S., D.T.M. (Sydney.) Field Medical Officer, Bulolo Gold Dredging Limited, Territory of New Guinea. At present with the Australian Medical Corps). **Practical Malaria Control.** 91 pp. Copyright 1944. Philosophical Library, Inc., New York.

Ham, Arthur W. (M.B. Associate Professor of Anatomy, in charge of Histology, Faculty of Medicine, University of Toronto. Honorary Secretary of the Banting Research Foundation), and M. D. Salter (M.A., Ph.D. Lecturer and Research Fellow in the Department of Psychology, Faculty of Medicine, University of Toronto). **Doctor in the Making.** xi + 179 pp. 3 parts, 11 chapters, illustrations by Jean McConnell, 3 pp. index. Copyright 1943. J. B. Lippincott Co., Phila., Pa. $2.00.

Huff, Clay G. (Sc.D. Professor of Parasitology, University of Chicago). **A Manual of Medical Parasitology.** x + 88 pp. 11 chapters, 10 plates, 132 text-figures, 8 pp. index. Copyright 1943. University of Chicago Press. $1.50.

Jaeger, Edmund C. (Riverside Junior College, Riverside, California). **A Source-Book of Biological Names and Terms.** xxvi + 256 pp. 96 figures. Copyright 1944. Charles C. Thomas, Springfield, Ill. $3.50.

Kouri, Pedro and Jose G. Basnuevo (Profesores de Parasitologia y Enfermedades Tropicales de la Universidad de la Habana). **Vademecum de Enfermedades Parasitarias y Tropicales,** editado por Laboratoros Kuba, S.A. Primera Parte: Tratamientos y Ciclos Evolutivos de las Helmintiasis Humanas; Segunda Parte: El Tratamiento de las Helmintiasis Humanas. 122 pp. 19 text-figures, 4 pp. index. Laboratorios Kuba.

Kudo, Richard R. (D.Sc. Associate Professor of Zoology, University of Illinois). **Manual of Human Protozoa.** ix + 125 pp. 11 chapters, 29 text-figures, 15 pp. subject index. Copyright 1944. Charles C Thomas, Springfield, Ill. $2.00.

Kudo, Richard R. (D.Sc. Associate Professor of Zoology, University of Illinois). **Morphology and Development of Nosema notabilis Kudo.** Illinois Biol. Monogr., Vol. XX, No. 1, 83 pp. 12 plates, 7 pp. author index. Copyright 1944. University of Illinois Press, Urbana, Ill. $1.25.

Nauss, Ralph Welty (B.Sc., M.D., Dr. P.H. Assistant Professor of Public Health and Preventive Medicine, Cornell University Medical College, New York. Lieutenant Colonel and Flight Surgeon, Medical Reserve Corps, United States Army). **Medical Parasitology and Zoology.** xix + 534 pp. 17 chapters, 15 tables, 90 text-figures, 9 pp. appendices, 40 pp. glossary, 18 pp. references, 36 pp. index. Copyright 1944. Paul B. Hoeber, Inc., New York. $6.00.

RAIFMAN, JOSE (Dr. Parasitólogo de las salas 1 y 2 del Hospital Nacional del Centenario, sección de Gastroenterología de la Facultad de Ciencias Médicas de la Universidad Nacional del Litoral. Miembro de la National gastroenterological Association de Nueva York). **El Isospora Bigeminum.** 31 microfotogratías, 4 dibujos y 2 estudios radiológicos ilustrados, 8 pp. index. Buenos Aires. 1944.

SEIFFERT, GUSTAV (Translation by Marion Lee Taylor, Ph.D.) **Virus Diseases in Man, Animal and Plant.** v-ix+332 pp. 7 tables, 10 pp. index. Copyright 1944. F. Hubner & Co., Inc., New York. The Philosophical Library Department of War Medicine, 15 East 40th St., New York. $5.00.

SOPER, FRED L. (M.D. International Health Division, Rockefeller Foundation) AND D. BRUCE WILSON (M.D. Rockefeller Foundation). **Anopheles gambiae in Brazil, 1930–1940.** xviii+262 pp. 5 plates, 75 text-figures, 49 tables, 3 pp. appendix, 4 pp. index. 1943. The Rockefeller Foundation, New York.

TALIAFERRO, WILLIAM H., Editor (Ph.D. Professor and Head of Department of Bacteriology and Parasitology, University of Chicago). **Medicine and the War.** Walgreen Foundation Lectures, 10 contributors. vii+193 pp. 5 text-figures, 1 table, 5 pp. subject index. Copyright 1944. University of Chicago Press. $2.00.

WILBUR, RAY LYMAN, Chairman, and others. **Report of the Baruch Committee on Physical Medicine.** 120 pp. 1 text-figure, no index. 1944.

AMERICAN SOCIETY OF PARASITOLOGISTS

Thirty-Third Council Meeting, Cleveland, Ohio

September 11, 1944

The meeting of the Council of the American Society of Parasitologists was called to order by Dr. H. E. Ewing, President of the Society, at 3:00 PM, September 11, 1944, in the Hotel Statler, Cleveland, Ohio. Past-presidents J. E. Ackert and G. R. La Rue and the following members of the Council were present: D. L. Augustine, R. M. Cable, J. T. Culbertson, H. E. Ewing, C. G. Huff, G. F. Otto, H. W. Stunkard, and W. H. Wright.

I. Reports of Officers

1. *Secretary (J. T. Culbertson):* As of August 15, 1944, there were 554 persons on the membership roll of the Society of which 493 lived within and 61 lived outside the continental United States. Of the total number on the roll, 448 were members in good standing and 106 were delinquent for one (50), two (31), or three (25) years. Of those in good standing 408 lived within and 40 lived outside the continental United States. Fifty new members were elected to date during 1944, of which 46 were domestic and 4 foreign. The death of one member occurred during the year: Father James J. Regan, St. Mary's Seminary, Baltimore, Maryland, on August 5, 1944.

Upon motion, the Secretary's report was accepted and placed on file.

2. *Treasurer (G. F. Otto):* On December 6, 1943, there was a balance on hand of $2957.16. Collections to September 1, 1944, from all sources during the year, including dues from members or applicants for membership, non-member subscriptions to Journal, sales of back numbers of Journal, copies of index, portraits, and advertisements, as well as interest on savings account, amounted to $4020.28. Total available funds, therefore, equalled $6977.44. Expenditures to September 1, 1944, were, for printing three numbers of Journal, $1629.36; for office of Chairman of Editorial Committee, $93.16; for office of Secretary, $184.77; for office of Treasurer, $334.75, these amounting altogether to $2242.04. As of September 1, 1944, there remains, therefore, a cash balance of $4735.40.

Upon motion, the Treasurer's report was accepted and placed on file, audit to be made at fiscal year-end.

II. Report of Committees

1. *Custodian of Princeton Secretarial Fund (N. R. Stoll):*

	Sept. 7, 1944	*Year ending Dec. 3, 1943*
A. Total liquid assets	$1023.45	$998.55
B. Total, last previous report	998.55	475.79
Gain in interim	$ 24.90	$522.76

Upon motion, report of Custodian was accepted and placed on file, audit to be made at end of fiscal year.

2. *Chairman of Editorial Committee (H. W. Stunkard):* Shortage of submitted manuscripts and labor shortage in the printer's office have been responsible for the tardy appearance of the 1944 numbers of the Journal. It is believed now, however, that enough material will be available to issue all six regular numbers of the Journal plus Supplement to the August issue. It is hoped that beginning with the October issue, numbers will appear on time.

Upon motion, the report was accepted.

III. Report of Representatives

1. *Representatives to Council of A.A.A.S.:* No report was received from the representatives to the Council of A.A.A.S.

2. *Representatives to Council of U.A.B.S. (A. C. Walton):* The Union of American Biological Societies was endeavoring to create an organization comprising all aspects of biology and able, therefore, to represent nationally all the biological sciences. The only publication which at the moment the Union proposed to sponsor was Biological Abstracts. It was hoped that every participating Society would contribute generously, a fixed fee being suggested, this based roughly on Society membership.

Following motion, Dr. Walton's report was accepted. Council then voted against contributing to the Union at this time.

IV. New Business

1. *New Members:* Council approved membership in the Society of nine applicants: Clyde Carlton Blackburn, Madison College, Tennessee; Hampton L. Carson, Zoology Department, Washington University, St. Louis, Missouri; Robert Greenwood Grocott, Board of Health Laboratory, Ancon, Canal Zone; Lt. Herman E. Marholin, 40th Malaria Survey Unit, A.P.O. 322, c/o P.M., San Francisco, California; Eleanor Mae Neumayer, Zoological Division, U. S. Bureau of Animal Industry, Beltsville, Maryland; Harry E. Ohl, 15th Medical General Laboratory, A.P.O. 534, c/o P.M., New York, N. Y.; Irwin H. Roberts, U. S. Bureau of Animal Industry, Albuquerque, New Mexico; William F. Simpson, Department of Biology, Catholic University of America, Washington, D. C.; Edward D. Wagner, Zoology Department, State College of Washington, Pullman, Washington.

2. *Management of Journal:* It was recommended by Council that Treasurer, Custodian of Journal stock, and Chairman of Editorial Committee endeavor to build up the reserve of back numbers of the Journal and extend Society funds for this purpose as necessary. Dr. Ackert recommended the reprinting of some Journal issues which now are short. The Council recommended a small increase in the number of exchanges, at the discretion of the Chairman of the Editorial Committee.

The establishment of a monograph series for the Journal was discussed, but no decision was reached on the matter. It was agreed that the present was an unfavorable time for initiating such a series. Council recommended that the Editorial Committee use its own discretion on charges to authors, varying its basic plan with variations in number of submitted manuscripts. The regular inclusion of an application form for membership in the Society was discussed. Earlier, Council had recommended inclusion.

3. *Place for Meeting in 1945:* No decision was reached as to the place for meeting in 1945.

4. *Nomination or Election of Officers, Appointments, etc.*

   a. The following persons were nominated by Council to the Society offices: A. C. Chandler, for President for the year 1945; D. L. Augustine, for Vice-President for the year 1945; R. M. Stabler, for Treasurer for two years beginning 1945; G. R. Coatney and G. F. Otto, for Councillors-at-Large for four years beginning 1945.

   b. The following persons were elected by Council to the Editorial Board of the Journal of Parasitology: C. W. Rees, L. A. Spindler, and W. L. Jellison.

   c. No appointments to standing committees were made, the President delaying these until later in the year.

Council voted its thanks to the Society Officers and Representatives and adjourned at 6:15 PM.

Respectfully submitted,
J. T. Culbertson, *Secretary.*

AMERICAN SOCIETY OF PARASITOLOGISTS

Nineteenth Annual Meeting, Cleveland, Ohio*

September 11 and 12, 1944

Minutes of General Business Meeting

The general business meeting of the Society was held at the Academy of Medicine, Cleveland, Ohio, on September 12, 1944. Twenty-five members of the Society were present. The meeting was called to order at 12:15 PM by President H. E. Ewing.

The reports of the Secretary, Treasurer, and Chairman of the Editorial Committee were presented to the Society, as was the report of the representatives to the Council of the Union of American Biological Societies.

The Secretary presented to the Society the names of persons nominated by Council for the Society offices. There were no further nominations and upon motion, duly seconded and carried, the Secretary was instructed to cast one ballot for the nominations as presented. Accordingly, the following persons were elected to the Society offices: President for one year, A. C. Chandler; Vice-President for one year, D. L. Augustine; Treasurer for two years, R. M. Stabler; Councillors-at-Large for four years, G. R. Coatney and G. F. Otto.

A vote of thanks was extended to Dr. Paul D. Harwood for his services as local representative in making arrangements for the Cleveland meeting.

At 1:15 PM, it was voted that the Society adjourn to convene again at a place and time selected by Council.

Respectfully submitted,
James T. Culbertson, *Secretary.*

---

* Prior to the scheduled meeting, the Program Committee found it necessary to comply with a directive from the Office of Defense Transportation urging cancellation of all meetings not directly related to the war. Accordingly, the general program of the Society was cancelled and only a Symposium on "Parasitology in Relation to the War" was held in Cleveland. Abstracts of all papers submitted for the meeting appeared in the Journal of Parasitology, August Supplement, 1944.

INDEX FOR VOLUME 30, NOS. 1-6

ADDIS, C. T. AND ASA C. CHANDLER. Studies on the vitamin requirement of tapeworms 229
Adelina deronis, coccidian parasite, factors influencing the course of infection 162
Alloglossidium corti, development of sporocyst stages 37
Amblyomma americanum, occurrence in Minnesota and Ohio 200
Amblyomma (Ixodidae) in the United States 77
AMEEL, DONALD J. The life history of *Nudacotyle novicia* Barker, 1916 (Trematoda: Notocotylidae) 257
AMEEL, DONALD J. (see Cort and Ameel) 37
AMEEL, DONALD J. (see Cort, Ameel and Olivier) 1
AMERICAN SOCIETY OF PARASITOLOGISTS:
Minutes, 19th annual meeting, Cleveland, Ohio 392
Minutes, 32nd council meeting 203
Minutes, 33rd council meeting, Cleveland, Ohio 390
Notice of partial cancellation of Cleveland program 275
Preliminary announcement of the 19th annual meeting 130
Second report of the committee on terminology of strains of avian malaria 206
War-time activities of 195
ANDERSON, DORCAS J. Studies on *Cercaria szidati* sp. nov., a furcocercous cercaria of the Vivax type 264
ARMER, SISTER JOSEPH MARIE. Influence of the diet of Blattidae on some of their intestinal Protozoa 131
Ascaridia galli, effect of nicotine-bentonite and phenothiazine on 143
Ascaris lumbricoides, effect of radiation on the eggs of 26
AUGUSTSON, GUSTAF F. A new mouse flea, *Pleochaetoides bullisi* n. gen., n. sp., from Texas 366
AUGUSTSON, GUSTAF F. The flea genus *Thrassis* and sylvatic plague, with the description of *T. brennani* n. sp. 237

Blattella germanica, cockroach, host of new parasitid mite 181
Blattidae, influence of diet on their intestinal Protozoa 131
Blood fluke, new cercaria of, from marine pelecypod 191
BOARDMAN, EDWARD T. Methods for collecting ticks for study and delineation 57
BRACKETT, STERLING (see Cort, Brackett and Olivier) 309
BRADY, FREDERICK J. AND ALFRED H. LAWTON. A new method for quantitative estimation of microfilariae in blood samples 34
BRAND, THEODOR VON AND W. F. SIMPSON. Physiological observations upon a larval *Eustrongylides.* VII. Studies upon survival and metabolism in sterile surroundings ... 121
Brevoortia tyrannus, host of *Eimeria brevoortiana* n. sp. 60
BUSHLAND, R. C., L. C. MCALISTER, JR., G. W. EDDY, HOWARD A. JONES AND E. F. KNIPLING. Development of a powder treatment for the control of lice attacking man 377

Cercaria marilli Ameel 1939, larval stage of *Nudacotyle novicia* 257
Cercaria talboti, development of sporocyst stages 37
Cestodes, vitamin requirements of 229
Chagas' disease, feeding habits of hemipterid vectors 197
CHANDLER, ASA C. A new species of *Mesocestoides, M. kirbyi,* from *Canis latrans* 273
CHANDLER, ASA C. (see Addis and Chandler) 229
CHEATUM, E. L. (see Goble and Cheatum) 119
CHEN, H. T. *Spelotrema pseudogonotyla* n. sp. (Trematoda: Microphallidae) from Hongkong 159
Chigger mites, morphology, life history, distribution, taxonomy and relation to disease 339
Coccidian infection of *Dero limosa,* factors influencing 162
COLE, C. L. (see Hawkins, Cole and Kline) 373
COOLEY, R. A. *Ixodes ozarkus* n. sp., and *Ornithodoros aquilae* n. sp. with notes on *O. talaje* and *O. kelleyi* (Ixodoidea) 287
COOLEY, R. A. AND GLEN M. KOHLS. The genus *Amblyomma* (Ixodidae) in the United States 77
CORT, W. W. AND D. J. AMEEL. Further studies on the development of the sporocyst stages of plagiorchiid trematodes 37
CORT, W. W., D. J. AMEEL AND LOUIS OLIVIER. An experimental study of the development of *Schistosomatium douthitti* (Cort, 1914) in its intermediate host 1

Cort, W. W., Sterling Brackett and Louis Olivier. Lymnaeid snails as second intermediate hosts of the strigeid trematode, *Cotylurus flabelliformis* (Faust, 1917) 309
Cotylurus flabelliformis, lymnaeid snails as second intermediate hosts 309
Culex molestus, insect host of filariid nematode of frogs 245

Davis, Helen Edith. *Cittotaenia sandgroundi,* a new anoplocephalid cestode from a Javanese tree duck 241
Denton, J. Fred. Studies on the life history of *Eurytrema procyonis* Denton, 1942 277
Development of *Hymenolepis* in mice, effect of concurrent infection with *Nippostrongylus* ... 18
Development of *Schistosomatium douthitti* in its intermediate host 1
Development of the sporocyst stages of the plagiorchiid trematodes 37
Dientamoeba fragilis, morphology, life history, diagnosis and host-relations 322
Diet of Blattidae, influence on intestinal Protozoa 131
Doetschman, Willis H. Notes on Anoplura infesting marine carnivores 200
Doll, R. B. (see Hauschka and Doll) 198
Donaldson, Alan W. (see Larsh and Donaldson) 18

Eddy, G. W. (see Bushland, McAlister, Eddy, Jones and Knipling) 377
Effect of concurrent infection with *Nippostrongylus* on the development of *Hymenolepis* in mice 18
Eimeria tenella, the respiration of 295
Embadomonas intestinalis, incidence in food handlers and diarrheic patients 34
Enterobius vermicularis, effect of radiation on the eggs 26
Eurytrema procyonis, the life history of 277
Eustrongylides ignotus, survival and metabolism of larvae in sterile surroundings 121
Ewing, H. E. The trombiculid mites (chigger mites) and their relation to disease 339
Exoerythrocytic stages of *Plasmodium durae* 177

Felsenfeld, Oscar. (see Young and Felsenfeld) 34
Filariae of amphibians 245
Fischthal, Jacob H. Observations on a sporozoan parasite of the eelpout, *Zoarces anguillaris,* with an evaluation of candling methods for its detection 35
Flea, new genus and species from mouse in Texas 366
Foleyella duboisi, morphology and life history of 245
Fujii, Harold. Three monogenetic trematodes from marine fishes 153

Gapeworm, *Syngamus trachea,* acquired resistance to 68
Gates, Doris B. *Xenopsylla cheopis* in Lincoln, Nebraska 202
Gerichter, Ch. (see Witenberg and Gerichter) 245
Giardia sanguinis, host of 202
Goble, Frans C. and E. L. Cheatum. Notes on the lungworms of North American Leporidae 119
Guthrie, James E. (see Harwood and Guthrie) 143
Guthrie, James E. (see Harwood and Guthrie) 197

Hardcastle, A. B. *Eimeria brevoortiana,* a new sporozoan parasite from Menhaden (*Brevoortia tyrannus*), with observations on its life history 60
Harwood, Paul D. and James E. Guthrie. The effect of nicotine-bentonite and of certain physical states upon the efficacy of phenothiazine against nematodes in fowls 143
Harwood, Paul D. and James E. Guthrie. The effect of prickly-ash bark upon the efficacy of phenothiazine against nematodes in fowls 197
Hauschka, Theodore. Season, nutrition, immunity, drugs and X-ray as factors influencing the course of a coccidian infection 162
Hauschka, T. S. and R. B. Doll. *Paraglaucoma sp.,* a facultative parasite of coelenterates 198
Hawkins, Philip A., C. L. Cole and E. E. Kline. Studies on sheep pastures. IV. Survival of sheep nematodes on pasture during the fall months 373
Herman, Carlton M. Notes on the pupal development of *Stilbometopa impressa* (Diptera: Hippoboscidae) 112
Herrick, C. A. (see Smith and Herrick) 295
Heterakis gallinae, effect of nicotine-bentonite and phenothiazine on 143
Hogue, M. J. *Trichomonas vaginalis* in the fluid of the vagina 34

HOLLAENDER, ALEXANDER. (see Jones and Hollaender) 26
Host relations of strigeid trematode, *Cotylurus flabelliformis* 309
Hymenolepis in mice, effect of infection with *Nippostrongylus* on the development of 18
Hymenolepis nana var. *fraterna*, development in different mice 21

Irradiation, effect of, on resistance of rats to infection by *Trypanosoma lewisi* 209
Ixodidae, *Amblyomma* in the United States 77
Ixodoidea, new species of *Ixodes* and *Ornithodoros* 287

JAMES, MAURICE T. Two erroneous records in American literature of the causative agents of myiasis 273
JONES, HOWARD A. (see Bushland, McAlister, Eddy, Jones and Knipling) 377
JONES, MYRNA F. AND ALEXANDER HOLLAENDER. Effect of long ultraviolet and near visible radiation on the eggs of the nematodes *Enterobius vermicularis* and *Ascaris lumbricoides* 26

KEEGAN, HUGH L. On a new genus and species of parasitid mite 181
KLINE, E. E. (see Hawkins, Cole and Kline) 373
KNIPLING, E. F. (see Bushland, McAlister, Eddy, Jones and Knipling) 377
KOHLS, GLEN M. (see Cooley and Kohls) 77

LARSH, JOHN E., JR. Comparative studies on a mouse strain of *Hymenolepis nana* var. *fraterna*, in different species and varieties of mice 21
LARSH, JOHN E., JR. AND ALAN W. DONALDSON. The effect of concurrent infection with *Nippostrongylus* on the development of *Hymenolepis* in mice 18
LAWTON, ALFRED H. (see Brady and Lawton) 34
Leishmania chagasi, identical with *L. donovani* 303
Leishmaniasis, etiological agent of American visceral type 303
Leporidae, lungworms of North American 119
Lice attacking man, powder treatment for control of 377
Lice, infesting marine carnivores 200
Life history of *Eimeria brevoortiana*, observations on 60
Life history of *Eurytrema procyonis* 277
Life history of *Folcyella duboisi* (Gedoelst, 1916) 245
Life history of *Nudacotyle novicia* 257
Lungworms of North American Leporidae 119

Macroderoides typicus, development of sporocyst stages 37
MARAVENTANO, L. W. (see Nigrelli and Maraventano) 184
Marine fishes, new monogenetic trematodes from 153
MARTIN, W. E. *Cercaria solemyae* n. sp., probably a blood fluke, from the marine pelecypod, *Solemya velum* 191
MCALISTER, L. S., JR. (see Bushland, McAlister, Eddy, Jones and Knipling) 377
MELENEY, HENRY E. War-time activities of members of the American Society of Parasitologists 195
Mesodon thyroidus, snail host of *Eurytrema procyonis* 277
Microfilariae, a new method for quantitative estimation of, in blood samples 34
Mole cricket, *Gryllotalpa hexadactyla*, host of new species of *Retortamonas* 173
Monogenetic trematodes from marine fishes 153
Myiasis, erroneous records of causative agents 273

NAIMAN, DOROTHY NEUHOF. Effect of x-irradiation of rats upon their resistance to *Trypanosoma lewisi* 209
Necator americanus, a mounting method for 201
Nematodes in fowls, effects of prickly-ash bark and phenothiazine against 197
Nematodes of sheep, survival on pasture during fall months 373
Neoechinorhynchus emydis, responses to various solutions 369
New genera (indicated *) and new species (volume 30, 1944):
Eimeria brevoortiana Hardcastle 60
Hexastoma macracanthum Fujii 153
Cyclocotyla hysteroncha Fujii 154
**Microcotyloides* Fujii, type *M. incisa* (Linton, 1910) 155
Paramphistomum microbothroides Price ..... Supplement, Abstract 13

Spelotrema pseudogonotyla Chen 159
Retortamonas wenrichi Stabler 173
**Transversotrema* Witenberg 179
**Blattisocius* Keegan 181
Diplostomulum xenopi 184
Cercaria solemyae 191
Thrassis brennani 237
Cittotaenia sandgroundi 241
Cercaria szidati 264
Pseudonymus brachycercus 269
Pseudonymus leptocercus 269
Mesocestoides kirbyi 273
**Barroella* Zeliff 275
Ixodes ozarkus 287
Ornithodorus aquilae 287
**Pleochaetoides bullisi* 366
Nicotine-bentonite, its effect on efficacy of phenothiazine 143
Nigrelli, Ross F. and L. W. Maraventano. Pericarditis in *Xenopus laevis* caused by *Diplostomulum xenopi* sp. nov., a larval strigeid 184
Nippostrongylus, effect of infections with, on the development of *Hymenolepis* in mice 18
Nudacotyle novicia Barker, life history of 257
Nyctotherus ovalis, effect of diet of host on 131

Olivier, Louis. Acquired resistance in chickens, turkeys, and ring-necked pheasants to the gapeworm, *Syngamus trachea* 69
Olivier, Louis. (see Cort, Ameel and Olivier) 1
Olivier, Louis. (see Cort, Brackett and Olivier) 309

Paraglaucoma sp., a facultative parasite of *Hydra* 198
Parasitid mite, a new genus and species from cockroach 181
Pericarditis in *Xenopus laevis* caused by larval strigeid 184
Phenothiazine, effect against nematodes of fowls 197
Phenothiazine, effect of nicotine-bentonite on its efficacy against fowl nematodes 143
Phlebotomus limai, occurrence in the United States 274
Physiological observations upon a larval *Eustrongylides* 121
Plagiorchiid trematodes, development of the sporocyst stages of 37
Plagiorchis micracanthos, development of sporocyst stages 37
Plagiorchis muris, development of sporocyst stages 37
Plagiorchis proximus, development of sporocyst stages 37
Plasmodium durae, exoerythrocytic stages of 177
Polymorphus sp., a hermit crab as intermediate host of 201
Pomatiopsis lapidaria, intermediate host of *Nudacotyle novicia* 257
Powder treatment for control of lice attacking man 377
Protostrongylus boughtoni in North American Leporidae 119
Pupal development of *Stilbometopa impressa* 112

Reinhard, Edward G. A hermit crab as intermediate host of *Polymorphus* (Acanth.) 201
Resistance of chickens, turkeys and pheasants to gapeworm 69
Resistance of irradiated rats to infections by *Trypanosoma lewisi* 209
Respiration of protozoan parasite, *Eimeria tenella* 295
Riley, William A. The occurrence of *Amblyomma americanum* in Minnesota and Ohio .. 200
Ross, Elizabeth L. (see Van Cleave and Ross) 369
Rozeboom, L. E. *Phlebotomus limai* Fonseca in the United States (Diptera: Psychodidae). 274

Schistosomatium douthitti (Cort, 1914), development in intermediate host 1
Senekjie, Harry A. American visceral leishmaniasis—the etiological agent 303
Sheep nematodes, survival on pastures 373
Simpson, Myron L. Exoerythrocytic stages of *Plasmodium durae* 177
Simpson, W. F. (see Brand and Simpson) 121
Smith, B. F. and C. A. Herrick. The respiration of the protozoan parasite, *Eimeria tenella* 295
Sporozoan parasite, *Eimeria brevoortiana*, from Menhaden (*Brevoortia tyrannus*) 60
Sporozoan parasite of the eelpout, *Zoarces anguillaris* 35

Stabler, Robert M. A new sepcies of *Retortamonas* (Protozoa) from the common mole cricket, *Gryllotalpa hexadactyla* 173
Stabler, Robert M. *Giardia sanguinis* (Gonder, 1911) not from a falcon 202
Stilbometopa impressa (Diptera: Hippoboscidae) pupal development of 112
Sullivan, Thelma D. Viability of *Trypanosoma cruzi* in citrated blood stored at room temperature 200
Sylvatic plague, relation of fleas of genus *Thrassis* to 237
Syngamus trachea, gapeworm, acquired resistance to 68
Synthetocaulus leporis in North American Leporidae 119

Thrassis, a review of the genus, relation to sylvatic plague, description of a new species 237
Ticks, methods for collecting 57
Todd, A. C. Two new nematodes from the aquatic beetle, *Hydrous triangularis* (Say) 269
Transversotreminae n. subfam. (Trematoda) 180
Triatoma spp., feeding habits of 197
Trichomonas vaginalis in the fluid of the vagina 34
Trombiculid mites, morphology, life history, taxonomy and relation to disease 339
Trypanosoma cruzi, new locality for 199
Trypanosoma cruzi, viability of in stored, citrated blood 200
Trypanosoma lewisi, effect of radiation of rats on resistance to 209
Tsutsugamushi disease, etiology and epidemiology 339
Typhus like diseases trombiculid mites 339

Van Cleave, Harley J. and Elizabeth L. Ross. Physiological responses of *Neoechinorhynchus emydis* (Acanthocephala) to various solutions 369
Vitamin requirements of cestodes 229
Vivax group of furcocercous cercariae, a new species and taxonomy of 264

Wenrich, D. H. Studies on *Dientamoeba fragilis* (Protozoa). IV. Further observations, with an outline of present-day knowledge of this species 322
Witenberg, G. *Transversotrema haasi*, a new fish trematode 179
Witenberg, G. and Ch. Gerichter. The morphology and life history of *Foleyella duboisi* with remarks on allied filariids of Amphibia 245
Wood, Sherwin F. An additional California locality for *Trypanosoma cruzi* Chagas in the western cone-nosed bug, *Triatoma protracta* 199
Wood, Sherwin F. Notes on the feeding of cone-nosed bugs (Hemiptera, Reduviidae) ... 197

Xenopsylla cheopis, in Nebraska 202

Yetwin, I. Jacques. A simple permanent mounting method for *Necator americanus* 201
Young, Viola Mae and Oscar Felsenfeld. The incidence of *Embadomonas intestinalis* Wenyon and O'Connor in food handlers and diarrheic patients of mental hospitals 34

Zeliff, C. Courson. *Barroella* n. nom. for *Kirbyella* Zeliff, 1930, homonym 275
Zoarces anguillaris, the eelpout, a sporozoan parasite of 35

INDEX FOR AUGUST SUPPLEMENT, 1944

(* refers to abstract number rather than page)

Acanthocephala, physiological responses of *Neoechinorhynchus emydis* to various solutions . 5*
Ackert, J. E., Dorothy S. Branson, D. J. Ameel and B. B. Riedel. Substitution of soybean oil meal for animal protein in developing resistance of animals to parasitism 26*
Ackert, J. E. and C. L. Wisseman. Studies on effects of helminths on growing chickens . 27*
Adelina deronis, parasite of *Dero limosa* 16*
Allen, Evelyn. (see Otto, Allen and Brackett) 21*
Ameel, D. J. (see Ackert, Branson, Ameel and Riedel) 26*
American Society of Parasitologists:
In memoriam 22
Members elected 1943–1944 23
Officers 19
Program 19th annual meeting, Cleveland, Ohio 1
Aryl arsonic acids, effect on experimental coccidiosis infection in chickens 3*
Ascaridia galli, effects of host starvation on 25*
Australorbis glabratus, elimination of by water flow 34*
Author Index 4

Bowman, George W. (see Hammond, Davis, Bowman and Simms) 4*
Brackett, Sterling. (see Otto, Allen and Brackett) 21*
Branson, Dorothy S. (see Ackert, Branson, Ameel and Riedel) 26*
Brown, Harold W. The present status of the filariasis problem 17
Bunostomum trigonocephalum, cause of anemia in lambs 18*

Cable, R. M. and Richard A. McLean. Motion picture of *Cercaria clausii* Monticelli, a marine rattenkönig larval trematode from the West Coast of Florida 8*
Cercaria clausii Monticelli, a marine rattenkönig larval trematode rfom the West Coast of Florida 8*
Chabertia ovina, further notes on 6*
Coccidiosis infection in chickens, effect of aryl arsonic acids on 3*
Culbertson, James T. (see Rose, Culbertson and Molloy) 39*
Culbertson, James T. and Harry M. Rose. Agglutination of microfilariae from *Litosomoides carinii* of the cotton rat by normal serums of man and other animals 23*

Davis, Leonard Reid. (see Hammond, Davis, Bowman and Simms) 4*
Dero limosa, infected with *Adelina deronis,* culture of 16*
Dove, Walter E. Development of louse powders for the armed forces 18
Dyer, R. E. Distribution and control of the fevers of the typhus group 17
Eimeria bovis, life cycle in calves 4*
Eimeria tenella, effects of sulpha drugs on 1*
Eimeria tenella, infections in poultry, sulfamethazine in treatment of 2*
Endamoeba histolytica, growth rates in cultures 19*
Ewing, Henry E. The trombiculid mites (chigger mites) and their relation to disease 40*

Felsenfeld, Oscar. On the staining of protozoa in human blood and feces 11*
Filariasis, an *in vitro* method for bio-assay of chemotherapeutic agents in 39*

Hammond, Datus M., Leonard Reid Davis, George W. Bowman and Bennett T. Simms. Experimental studies on the life cycle of *Eimeria bovis* in calves 4*
Harwood, Paul D. (see McMullen, Van Volkenberg and Harwood) 31*
Hauschka, Theodore S. The continuous culture of pure clones of *Dero limosa* infected with *Adelina deronis* 16*
Hawkins, Philip A. Sulfamethazine in the treatment of *Eimeria tenella* infections in poultry 2*
Helminths, common names of 31*
Helminths, effects on growing chickens 27*
Hinshaw, W. R. (see MacNeil and Hinshaw) 15*
Histoplasma capsulatum, its biochemical and immunological properties 9*

(* refers to abstract number rather than page)

Hymenolepis nana var. *fraterna*, effect of alcoholism on resistance to 29*

LARSH, JOHN E. Alcoholism in mice and its effect on natural and acquired resistance to *Hymenolepis nana* var. *fraterna* 29*
Life cycle of *Eimeria bovis* in calves, experimental studies on 4*
Litosomoides carinii, agglutination of microfilariae by sera 23*
LUCKER, JOHN T. AND ELEANOR M. NEUMAYER. The production of anemia in lambs by hookworms, *Bunostomum trigonocephalum* 18*
LUTTERMOSER, GEORGE W. The possibility of eliminating the schistosome snail, *Australorbis glabratus*, from canals by controls of water flow 34*

MACNEIL, E. AND W. R. HINSHAW. A blood parasite of the turkey 15*
MAYFIELD, ORLEY J. (see Morehouse and Mayfield) 3*
MAHEW, ROY L. The effects of nematode infections during the prepatent period on the calf.. 28*

MCINTOSH, ALLEN (see Price and McIntosh) 13*
MCLEAN, RICHARD A. (see Cable and McLean) 8*
MCMULLEN, DONALD B., H. L. VAN VOLKENBERG AND PAUL D. HARWOOD. Common names of helminths 31*
Microfilariae of *Litosomoides carinii*, agglutination by sera 23*
MOLLOY, ELEANORA (see Rose, Culbertson and Molloy) 39*
MOREHOUSE, NEAL F. AND ORLEY, J. MAYFIELD. The effect of some aryl arsonic acids on experimental coccidiosis infection in chickens 3*
MORGAN, BANNER BILL. Inoculations of *Trichomonas foetus* (Protozoa) in heifers 20*

Necator americanus, action of sera on infective larvae 21*
Nematode infections, effect on the calf 28*
Nematodes of swine, effects of skim milk on 38*
Neoechinorhynchus emydis (Acanthocephala), physiological responses to various solutions.. 5*
NEUMAYER, ELEANOR M. (see Lucker and Neumayer) 18*
NEWTON, WALTER L. AND WILLARD H. WRIGHT. Tests to determine the ability of species of domestic mosquitoes to transmit *Wuchereria bancrofti* 22*
NIGRELLI, ROSS F. Trypanosomes of North American amphibians 14*

OLIVER-GONZÁLES, JOSÉ. Cross reactions between polysaccharides from various animal parasites 24*
OLSEN, O. WILFORD. Critical tests with a hexachloroethane-bentonite-water suspension as a fasciolicide in cattle 30*
OTTO, GILBERT F., EVELYN ALLEN AND STERLING BRACKETT. The action of Negro and white sera on infective hookworm (*Necator americanus*) larvae 21*

Paramphistomes of North American domestic ruminants 13*
Parasitology in relation to the war symposium, Cleveland, Ohio, program of 5
Plethodontidae (Amphibia-Caudata), the parasites of 35,* 36*
Polysaccharides from various animal parasites, cross reactions between 24*
Porocephalus crotali Humbolt, occurrence of, in rattlesnakes of southwestern Oklahoma 12*
PRICE, EMMETT W. AND ALLEN MCINTOSH. Paramphistomes of North American domestic ruminants 13*
Proteidae (Amphibia-Caudata), the parasites of 37*
Protozoa, incidence of intestinal, in mental patients and in cases showing symptoms of amoebic dysentery 10*
Protozoa, staining of, in human blood and feces 11*

REARDON, LUCY V. (see Rees and Reardon) 19*
REES, CHARLES W. AND LUCY V. REARDON. Comparative growth rates of amoebae and bacteria in cultures of *Endamoeba histolytica* and organism *t*. 19*
REID, W. MALCOLM. The effects of host starvation on worm elimination and glycogen depletion with the nematode, *Ascaridia galli* 25*
RELLER, HELEN (see Tsuchiya and Reller) 17*
RIEDEL, B. B. (see Ackert, Branson, Ameel and Riedel) 26*

(* refers to abstract number rather than page)

RIPSOM, CHARLES A. Effects of various sulpha drugs on the protozoan parasite, *Eimeria tenella* 1*
ROSE, HARRY M. (see Culbertson and Rose) 23*
ROSE, HARRY M., JAMES T. CULBERTSON AND ELEANORA MOLLOY. An *in vitro* method for the bio-assay of chemotherapeutic agents in filariasis 39*
ROSS, ELIZABETH L. (see Van Cleave and Ross) 5*

SCHEFF, GEORGE J. *Histoplasma capsulatum,* its biochemical and immunological properties.. 9*
SCHWARTZ, BENJAMIN. Parasites as factors in production of meat and other animal products in wartime 18
SEITNER, PHILIP G. Studies on a new xiphidiocercaria of the virgula type with notes on the life history 7*
SELF, J. TEAGUE. The occurrence of the pentastomid, *Porocephalus crotali* Humbolt, in rattlesnakes of southwestern Oklahoma 12*
SIMMS, BENNETT T. (see Hammond, Davis, Bowman and Simms) 4*
Sirenidae (Amphibia-Caudata), the parasites of 37*
SMITH, VIVIAN S. A reaction of rat serum to embryonated eggs of *Trichosomoides crassicauda* 32*
SMITH, VIVIAN S. Studies on the relationship of *Trichosomoides crassicauda* infection in rats to mucoid calculi of the urinary bladder 33*
SPINDLER, L. A. AND HARRY E. ZIMMERMAN, JR. Effect of skim milk on infections of ascarids, whipworms and nodular worms in swine 38*
Sulpha drugs, effects on protozoan parasite, *Eimeria tenella* 1*
Sulfamethazine in the treatment of *Eimeria tenella* infections in poultry 2*
Symposium on parasitology in relation to the war, Cleveland, Ohio, program of 5

THRELKELD, W. L. Further notes on *Chabertia ovina* 6*
Trichomonas foetus, inoculations in heifers 20*
Trichosomoides crassicauda, infection in rats and mucoid calculi of urinary bladder 33*
Trichosomoides crassicauda, reaction of rat serum to embryonated eggs of 32*
Trichostrongylus sp. and identification of ova 17*
Trypanosomes of North American amphibians 14*
TSUCHIYA, H. AND HELEN RELLER. A case of *Trichostrongylus sp.* with notes on the identification of ova 17*

VAN CLEAVE, HARLEY J. AND ELIZABETH L. ROSS. Physiological responses of *Neoechinorhynchus emydis* (Acanthocephala) to various solutions 5*
VAN VOLKENBERG, H. L. (see McMullen, Van Volkenberg and Harwood) 31*

WALTON, ARTHUR C. The parasites of the Plethodontidae (Amphibia-Caudata) III and IV 35*, 36*
WALTON, ARTHUR C. The parasites of the Proteidae and the Sirenidae (Amphibia-Caudata) 37*
WISSEMAN, C. L. (see Ackert and Wisseman) 27*
WRIGHT, WILLARD H. (see Newton and Wright) 22*
Wuchereria bancrofti, transmission by domestic mosquitoes 22*

Xiphidiocercaria of the virgula type 7*

YOUNG, VIOLA M. The incidence of intestinal protozoa in mental patients and in cases showing symptoms of amoebic dysentery 10*

ZIMMERMAN, HARRY E. (see Spindler and Zimmerman) 38*